**Institute on Science for Global Policy (ISGP)**

# Emerging and Persistent Infectious Diseases: Focus on Surveillance

**Conference convened Oct. 17-20, 2010**
**At Airlie Conference Center, Warrenton, Virginia**

# Acknowledgment

Numerous individuals and organizations have made important contributions to the Institute on Science for Global Policy (ISGP) program on Emerging and Persistent Infectious Diseases (EPID). Some of these contributions directly supported the efforts needed to organize and convene the ISGP conference on EPID: Surveillance held at the Airlie Conference Center in October 2010. Other contributions aided the ISGP in preparing the material presented in this book that records the views presented and the critical debates and caucuses that ensued.

The process began with the early recognition that EPID and related aspects of food safety and security are topics that deserved the significant attention from both domestic and international policy makers. The willingness of those in the scientific and policy communities having expertise and experience with EPID to be interviewed by the ISGP staff was a critical early step in creating and updating the Strategic Roadmap on EPID. The resultant Strategic Roadmap describes the two-year series of ISGP conferences focused on different policy aspects of EPID. The endorsement of and support for the EPID Strategic Roadmap by the governments engaged with the ISGP facilitated the launching of the EPID conference series by convening the October 2010 EPID: Surveillance event.

The efforts of the scientific presenters invited by the ISGP in both preparing policy position papers and engaging policy makers in vigorous debates were especially appreciated. Their biographies are provided in the book.

No less critical to the success of the program were the often intense debates that originated between the scientific presenters and the subject matter experts and policy makers invited by the participating governments to comprise the audience. The exchange of strongly held views, innovative proposals, and critiques generated from questions and debates fostered an unusual, even unique, environment focused on clarifying understanding for the non-specialist and addressing specific questions related to formulating effective public policy pertaining to EPID.

The ISGP is indebted to all those who participated in these vigorous, not-for-attribution debates and caucuses.

The energetic, highly professional work of the ISGP staff merits special acknowledgment. Their outstanding interviewing, organizing, and writing skills were essential to recording the often-diverse views and perspectives comprising the debates, capturing the areas of consensus and next steps from the caucuses, and persevering though the extensive editing process needed to assure the accuracy of the material published here. All of their work is gratefully acknowledged. Their biographies are provided in the book.

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January 21, 2011

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# Introduction

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## Preface

The contents of this book are taken from the presentations, debates, and conclusions made at an international conference convened by the Institute on Science for Global Policy (ISGP). This ISGP conference, held on October 17-20, 2010, at the Airlie Conference Center in Virginia, addressed topics involving surveillance aspects of Emerging and Persistent Infectious Diseases (EPID) and aspects of Food Safety and Security (FSS) related to infectious diseases. While the material presented here is comprehensive and stands by itself, its policy significance is best appreciated if viewed within the context of how domestic and international science policies have been, and often currently are being, formulated and implemented.

## Current realities

As the first decade of the 21st century closes, most societies are facing difficult decisions concerning how to appropriately use, or reject, the dramatic new opportunities offered by modern scientific advances and the technologies that emanate from them. Advanced scientific research programs, as well as commercially viable technologies, are now developed globally. As a consequence, many societal issues based on science and technology (S&T) necessarily involve both domestic and international policy decisions. The daunting challenges to simultaneously recognize immediate technological opportunities, while identifying those emerging and "at-the-horizon" S&T achievements that foreshadow transformational advantages and risks, are now fundamental governmental responsibilities. These responsibilities are especially complex since policy makers must consider the demands of different parts of society often having conflicting goals. For example, decisions must balance critical commercial interests that promote economic prosperity with the cultural sensitivities that often determine if, and how, S&T can be successfully integrated into any society.

Many of our most significant geopolitical policy and security issues are directly connected with the remarkably rapid and profound S&T accomplishments of our time. Consequently, it is increasingly important that the S&T and policy communities communicate effectively. With a seemingly unlimited number of urgent S&T challenges, both developed and developing societies need the most accomplished members of these communities to focus on effective, real-world solutions. Some of the most prominent challenges involve infectious diseases and pandemics, environmentally compatible energy sources, the consequences of climate change, food safety and security, the cultural impact of stem cell applications, nanotechnology and human health, cyber security for advanced telecommunication, the security implications of quantum computing, and the cultural radicalization of societies.

Recent history suggests that most societies would benefit from improving the effectiveness of how scientifically credible information is used to formulate and implement governmental policies, both domestic and international. Specifically, there is a critical need to have the relevant S&T information concisely presented to policy communities in an environment that promotes candid questions and debates led by those non-experts directly engaged in decisions. Such discussions, sequestered away from publicity, can help to clarify the advantages and potential risks of realistic S&T options directly relevant to the challenges being faced. Eventually, this same degree of understanding, confidence, and acknowledgment of risk must be communicated to the public to obtain the broad societal support needed to implement any decision.

### The ISGP mission

The Institute on Science for Global Policy (ISGP) has pioneered the development of a new type of international forum based on a series of invitation-only conferences. These ISGP conferences are designed to provide articulate, distinguished scientists and technologists opportunities to concisely present their views of the credible S&T options available for addressing major geopolitical and security issues. Over a two-year period, these ISGP conferences are convened on different aspects (e.g., surveillance, prevention, or mitigation) of a broad, overarching topic (currently, EPID). The format used emphasizes written and oral, policy-oriented S&T presentations and extensive debates led by an international cross section of the policy community.

The current realities, relevant S&T-based options, and policy issues are debated among a few scientists selected by the ISGP and an international group of government, private sector, and societal leaders selected primarily by the participating governments. ISGP conferences reflect global perspectives and seek to provide government and community leaders with the clear, accurate understanding of the real-world challenges and potential solutions critical to determining sound public policies.

ISGP programs rely on two overarching principles:

1. The value of ensuring that science-based understanding is closely linked to realistic policy decisions made by societal leaders, and endorsed and supported by the public.

2. The importance of venues where internationally distinguished scientists candidly debate policy makers concerning scientifically credible options, and associated risks, available to effectively address the major challenges facing 21$^{st}$ century societies worldwide.

### Historical perspective

The dramatic and rapid expansion of academic and private sector scientific research transformed many societies of the 20$^{th}$ century and is a major factor in the emergence of the developed countries that currently dominate the global economic and security landscape. The positive influence of these S&T achievements has been extremely impressive and in many ways the hallmark of the 20$^{th}$ century. However, there have also been numerous negative consequences, some immediately apparent and others appearing only recently. From both perspectives, it would be difficult to argue that S&T has not been the prime factor defining the societies we know today. Indeed, the 20$^{th}$ century can be viewed through the prism of how societies decided to use the available scientific understanding and technological expertise to structure themselves. Such decisions helped shape the respective economic models, cultural priorities, and security commitments in these societies.

It remains to be seen how the prosperity and security of 21$^{st}$ century societies will be shaped by the decisions made by our current leaders, especially with respect to how these decisions reflect sound S&T understanding.

Given the critical importance of properly incorporating scientifically credible information into major societal decisions, it is surprising that the process by which this is achieved by the public and its political leadership has been uneven and, occasionally, haphazard. In the worst cases, decisions have been based on unrecognized misunderstanding, over-hyped optimism, and/or limited respect for potentially negative consequences. Retrospectively, while some of these outcomes may be attributed to politically motivated priorities, the inability of S&T experts to accurately communicate the advantages and potential risks of a given option must also be acknowledged as equally important.

The new format found in ISGP programs seeks to facilitate candid communication between scientific and policy communities in ways that complement and support the efforts of others.

It is important to recognize that policy makers routinely seek a degree of certainty in evaluating S&T-based options that is inconsistent with reality, while S&T experts often overvalue the potentially positive aspects of their proposals. Finite uncertainty is always part of advanced scientific thinking and all possible positive outcomes in S&T proposals are rarely realized. Both points need to be reflected in policy decisions. Eventually, the public needs to be given a frank, accurate assessment of the potential advantages and foreseeable disadvantages associated with these decisions. Such disclosures are essential to obtain the broad public support required to effectively implement any major decision.

**ISGP conference structure**

The October, 2010, ISGP conference addressing EPID and FSS focused on surveillance issues.

Prior to the EPID/FSS conference, the ISGP invited eight internationally recognized, subject-matter experts to prepare concise (three pages) policy position papers describing their views on current realities, scientifically credible opportunities now available together with the associated risks, and the domestic and international policy issues involved. These individuals were chosen to represent a broad cross section of viewpoints and an international perspective. Several weeks before the conference convened, these policy position papers were distributed to representatives from governments and regions engaged with the ISGP (the United States, Italy, the United Kingdom, Japan, Canada, Germany, Singapore, and Hong Kong). Individuals from several private sector and philanthropic organizations were also invited to participate and therefore, to receive the papers. All participants had responsibilities and/or made major contributions to the formulation and implementation of domestic and international policies related to EPID and FSS.

The conference agenda was comprised of eight, 90-minute sessions, each of which was devoted to a debate of a given policy position paper. To encourage frank discussions and critical debates, all ISGP conferences are conducted under the Chatham House Rule (i.e., all the information can be used freely, but there can be no attribution of any remark to any participant). Each author was given 5 minutes of each 90-minute session to summarize his or her views while the remainder of the period was opened to all participants, including other authors, for questions, comments, and debate. The focus was on obtaining the clarity of understanding among the non-specialists and identifying areas of consensus and actionable policy decisions supported by scientifically credible information. With active participation from North America, Europe, and Asia, these candid debates reflected international perspectives on real-world problems.

The ISGP staff attended the debates of all eight policy position papers. The “not-for-attribution” summaries of each debate, prepared from their collective notes, are presented here immediately following each policy position paper. These summaries represent the ISGP's best effort to accurately capture the comments and questions made by the participants, including the other authors, as well as those responses made by the author of the paper (or in one case, his representative). The views expressed in these summaries do not necessarily represent the views of a specific author, as evidenced by his or her respective policy position paper. Rather, the summaries are, and should be read as, an overview of the areas of agreement and disagreement that emerged from all those participating in the debates.

Following the eight debates, caucuses were held by each country delegation and, separately, for the scientific presenters and for participants from the private sector and philanthropic organizations. These caucuses focused on identifying areas of consensus and actionable next steps for consideration within governments and civil societies in general. Subsequently, a plenary caucus was convened for all participants to obtain international perspectives on the recommendations made by the country caucuses. While the debates focused on specific issues and recommendations raised in each policy position paper, the caucuses focused on overarching views and conclusions that could have policy relevance both domestically and internationally.

A summary of the overall areas of consensus and actionable next steps emerging from these caucuses is presented here immediately following this introduction under the title of **Conference conclusions.**

**Concluding remarks**

ISGP conferences are designed to provide a new and unusual (perhaps unique) environment that facilitates and encourages candid debate of the credible S&T options vital to successfully addressing many of the most significant challenges facing 21st century societies. ISGP debates test the views of subject matter experts through critical questions and comments from an international group of decision makers committed to finding effective, real-world solutions. Obviously, ISGP conferences build on the authoritative reports and expertise expressed by many domestic and international organizations already actively devoted to this task. The ISGP has no preconceived opinions nor do members of the ISGP staff express any independent views on these topics. Rather, ISGP programs focus on fostering environments that can significantly improve the communication of ideas and recommendations, many found in the reports developed by other organizations and institutes, to the policy communities responsible for serving their constituents.

ISGP conferences begin with concise descriptions of scientifically credible options provided by those experienced in the S&T subject, but rely heavily on the willingness of non-specialists in government, academe, foundations, and the private sector to critically debate these S&T concepts and proposals. Overall, ISGP conferences seek to provide new venues in which S&T expertise not only informs the non-specialists, but also in which the debates and caucuses identify realistic policy options for consideration by governments and society leaders. With success, these new ISGP programs can help ensure that S&T understanding is integrated into those real-world policy decisions needed to foster safe and prosperous 21st century societies.

# Conference conclusions

**Area of consensus 1:**

Effective disease surveillance, encompassing those activities focused on protecting human health, remains essential to identifying the basic information required to effectively control and treat infectious diseases. The collection of these data must serve priorities ranging from those defined by local outbreaks to global pandemics. Disease surveillance data, however, are not normally sufficient themselves to support major governmental and societal decisions concerning infectious diseases at almost any level. Only when surveillance data are coupled with accurate analyses and timely modeling, can the public and its governments be given the degree of certainty normally needed to commit the significant human and financial resources required to address infectious diseases, locally or globally.

**Actionable next steps:**

1. Organizational structures and responsibilities, spanning both domestic and international programs, must be reformulated to better coordinate and integrate the often divergent priorities of those engaged in disease surveillance. Standardizing the type of disease surveillance data collected and the format in which they are recorded would dramatically reduce the duplication of field programs, maximize the impact of limited human and financial resources, and optimize the policy value of the information obtained from accurate analyses and timely modeling.

2. Disease surveillance data collected must be more widely and quickly shared among networks of health professionals at local, regional, national, and international levels. Such wide ranging collaboration can be enhanced by transferring major decisions on data collection to local and regional levels where the specific needs are more accurately understood and surveillance can be more efficiently implemented.

3. Transporting humans, livestock, plants, and food plays an overarching, and potentially critical, role in the appearance and transmission of infectious diseases and must be recognized as a priority in designing and implementing surveillance programs. As the geographic scale and speed of cross-border transportation, particularly by air, continues to increase, significantly more comprehensive policies concerning surveillance are needed. Appropriate attention must be given to the economic and privacy issues associated with policies used to monitor diseases through the inspection of people and goods crossing borders.

4. The enhancement of local capacities, especially in less-wealthy countries and in poorer localities within wealthy countries, is crucial to any disease surveillance system designed to serve regional, national, and international networks. Such enhanced local capacity must include significant physical improvements in facilities and better training for laboratory diagnostics, epidemiology, public health, and veterinary medicine. Increased allocation of in-country resources to surveillance is needed to ensure that decisions reflecting local priorities are given appropriate attention. Nonetheless, the surveillance data obtained locally must be effectively integrated into the comprehensive analyses and modeling programs used to accurately inform regional, national, and international networks in a timely manner.

**Area of consensus 2:**

The degree to which human health can be protected depends directly on the effectiveness with which infectious diseases in animals can be monitored and understood. Disease surveillance data from both animals and humans must be continuously analyzed in a coordinated manner and the resultant information integrated into a comprehensive program focused on the mitigation and control of infectious diseases in humans.

**Actionable next steps**

1. Greater focus must be placed on the "One Health" approach to foster collaborations between the human and animal disease surveillance communities. These interdisciplinary linkages must be based on the adoption of common terminologies, methodologies, priorities, and goals.

2. Given that rapid identification of animal and plant disease outbreaks is increasingly critical to protecting human health, practical incentives must be found that encourage the accurate and timely reporting of livestock and plant disease(s) to public health officials. Currently, such reporting frequently is viewed as punitive by food producers and governments.

**Area of consensus 3:**

Comprehensive definitions for myriad types of disease surveillance now in use must be established and broadly accepted to provide the "common language and lexicon" fundamental to accurate and timely communications among scientists, public health officials, policy makers, and particularly the public. Such lexicons, if commonly understood and used by these communities, would help governments and publics they serve make the commitments needed to significantly improve disease surveillance.

**Actionable next steps:**

1. Lexicons for disease surveillance must delineate the respective arenas of application (e.g., animal, human, or both), priorities, anticipated goals, and in-field methodologies.

2. The relative importance of different disease surveillance methods and a clearer understanding of their respective impact on analyses and modeling need to be identified. Ensuring that each disease surveillance system is defined in terms of its limitations and the primary factors potentially influencing the validity of the resultant findings (e.g., climatic, social, or ecological issues) must become an integral part of these lexicons.

**Area of consensus 4:**

Findings from disease surveillance, even after proper analysis and modeling, have often not been effectively used by governmental or societal leaders to shape policy. The effective use of disease surveillance data in policy decisions needs to be substantially improved. Scientific and public health experts must convey clear, consistent messages to policy makers in a manner which promotes timely policy decisions. These policy decisions and the relevant information concerning the background science need to be collectively communicated to the public.

**Actionable next steps:**

1. Scientists and public health experts need to improve their abilities to effectively communicate the significance of disease information derived from surveillance, analysis, and modeling to policy makers. It is important to bridge this communication gap at the local, regional, national, and international levels. Such messages must (i) provide an accurate description of the severity of the disease(s), (ii) describe the medical consequences associated with contracting the disease(s), and (iii) acknowledge the effectiveness and potential risks of known treatments.

2. Scientists, public health experts, and policy makers collectively are responsible for providing the public accurate and consistent information concerning disease outbreaks. Such information must describe the severity of the outbreak and medical consequences of contracting the disease(s). No less important is an acknowledgment of the effectiveness and potential risks of known treatments. The terms used in such communications must be relevant to a layperson's concerns and understanding.

3. Major improvements in communication must be adopted that (i) reduce the current level of public distrust of science-based advice, (ii) help formulate sound strategic policies to meet local, regional, national, and international priorities, and (iii) establish the degree of public confidence needed to effectively mitigate and control a disease outbreak.

4. Improved cooperation with the media, including social media, is essential to effectively communicate to the public accurate and timely information concerning infectious diseases. The effectiveness of communications from all forms of media often determines how well the public participates in implementing these policies. The focus must remain on identifying scientifically credible information for the media and encouraging the media to remain committed to substantiating the information it conveys to the public.

**Area of consensus 5:**

The institutions mandated with the responsibility for protecting world health must better coordinate their respective disease surveillance efforts. These institutions must significantly improve their collaborative contributions in shaping disease surveillance programs, interpreting the programs' results, and utilizing credible findings to influence infectious disease policies. Of specific importance is the need for timely national and international decisions that facilitate proactive activities (e.g., vaccination) that can prevent and mitigate the local impact of a disease outbreak, control wide-ranging disease transmission, and potentially prevent pandemics.

**Actionable next steps:**

1. Significantly more coordination among the programs managed by the major national and international agencies and organizations, all having infectious disease expertise and policy responsibilities, is urgently needed to properly address the growing challenges presented by disease surveillance. Key to such coordination is their commitment to align their program goals and financial priorities to help optimize the use of limited human and financial resources. These realigned mandates must focus on evaluating the continuous flow of disease surveillance data in a timely manner consistent with initiating the actions required to mitigate and control localized disease outbreaks and to prevent pandemics.

2. Expanding the private sector's role in disease surveillance by strengthening public-private partnerships at the local, regional, national, and international levels is critical to enhancing the impact of surveillance information on the control and treatment of infectious diseases. Private-public partnerships are likely to increase the human and financial resources available for disease surveillance and stimulate research into vaccine and drug development associated with disease surveillance.

**Area of consensus 6:**

Systems for disease surveillance must remain flexible enough to embrace techniques and methodologies shown to have predictive value in the detection and control of diseases. The complexity surrounding how and where infectious diseases appear suggests that environmental, social, ecological, and syndromic factors are potentially useful in surveillance models. However, it remains to be demonstrated conclusively that the inclusion these types of factors can make major contributions to disease surveillance. Nonetheless, rapid advances in the scientific understanding of infectious diseases also suggest that new linkages to such factors may be found.

**Actionable next steps:**

1. Given concerns about the predictive value of syndromic data for disease surveillance, the credibility of this relationship must be definitively established or rejected. The level of human and financial resources currently allocated to syndromic surveillance as part of overall disease surveillance programs is a major concern.

2. The potential importance of weather and climate in the collection, analysis, and modeling of disease surveillance data merits increased attention, especially in view of concerns over significant climatic changes in geographic regions that currently have major disease burdens.

3. Given that local environmental conditions, social practices, and ecological characteristics are thought to influence the appearance and spread of infectious diseases, incorporating expertise from these areas into the design and implementation of disease surveillance, analysis, and modeling programs is increasingly important. Thus, education and training spanning such disciplines not traditionally associated with infectious diseases might open new opportunities to improve the credibility of information from disease surveillance. This improved credibility is especially important for policy makers and the public.

**Area of consensus: 7**

The global nature of the food supply chain, coupled with the often direct linkage between animal and plant diseases and human health, requires a more dynamic, comprehensive, and robust surveillance system focused on the pathogens associated with foodborne diseases. The world's reliance on a just-in-time supply system, with its emphasis on rapid global transportation of livestock, plants, and food, makes monitoring foodborne diseases especially complex. These trends are expected to continue given burgeoning worldwide populations, growing interdependence of transportation systems, and economic pressures to diversify food sources driven by lower costs in countries having little capacity for food safety measures.

**Actionable next steps:**

1. An essential part of surveillance of foodborne pathogens must focus on accurately and rapidly identifying the source(s) of the food(s) or ingredient(s) involved. Specificity in such attribution is remarkably difficult given the diversity of the sources routinely used in the global food system.

2. While most occurrences associated with foodborne diseases are unintentional, growing concerns over terrorist activities demand attention be given to the intentional introduction of pathogens into food supply. Preventing natural and intentional harm to the food supply is of utmost importance for domestic and international security and economic well-being.

3. The historical reliance on the private sector in managing the detection of foodborne pathogens and diseases, as well as in controlling the process of reporting the findings, deserves re-examination. While the role of the private sector has been productive, the complexity of the global food system, the diversity of how credible and false information now can be communicated publicly, and the potential role of terrorist activities all illustrate the growing vulnerability of the food supply. The distribution of surveillance and reporting responsibilities between private sector and governmental institutions requires attention, especially for establishing public trust in specific recommendations.

## ISGP conference program

**<u>Sunday, October 17</u>**

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|---|---|
| 12:00 – 17:00 | **Arrival and registration: Airlie Center** |
| 17:30 – 19:00 | *Reception* |
| 19:00 – 20:00 | *Dinner* |

**<u>Monday, October 18</u>**

| | |
|---|---|
| 07:00 – 08:00 | *Breakfast* |
| 08:00 – 08:30 | **Welcome and opening remarks**<br>Dr. George Atkinson, Director, ISGP, and debate moderator |

**Presentations and debates: Session 1**

| | |
|---|---|
| 8:30 – 10:00 | **Prof. Stephen S. Morse, Columbia University**<br>*Early Warning: The Necessary Beginning* |
| 10:00 – 10:30 | *Break* |
| 10:30 – 12:00 | **Dr. Duane J. Gubler, Duke University, National University of Singapore and University of Hawaii**<br>*Emerging Infectious Diseases in the 21st Century: A Threat to Global Economic Security* |
| 12:30 – 13:30 | *Lunch* |

**Presentations and debates: Session 2**

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|---|---|
| 13:30 – 15:00 | **Dr. Nathan Wolfe, Global Viral Forecasting Initiative and Stanford University, presented by Dr. Travis Taylor, Global Viral Forecasting Initiative**<br>*The Transition from Pandemic Response to Pandemic Prevention* |
| 15:00 – 15:30 | *Break* |
| 15:30 – 17:00 | **Prof. Arthur L. Reingold, University of California, Berkeley**<br>*Novel Surveillance Systems: Good Value for the Money Spent?* |
| 18:00 – 19:00 | *Reception* |
| 19:00 – 21:00 | *Dinner and program,* **Dr. Peter Hotez, Sabin Vaccine Institute and George Washington University** |

**<u>Tuesday, October 19</u>**

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|---|---|
| 07:00 – 08:00 | *Breakfast* |

**Presentations and debates: Session 3**

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|---|---|
| 08:00 – 09:30 | **Dr. Madeleine C. Thomson, International Research Institute for Climate and Society and Columbia University**<br>*Integrating Climate Information into Surveillance Systems for Infectious Diseases: New Opportunities for Improved Public Health Outcomes in a Changing Climate* |
| 09:30 – 10:00 | *Break* |
| 10:00 – 11:30 | **Prof. Kennedy F. Shortridge, University of Hong Kong**<br>*Whither Surveillance?* |
| 11:30 – 12:30 | *Lunch* |

**Presentations and debates: Session 4**

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|---|---|
| 12:30 – 14:00 | **Dr. Robert E. Brackett, Illinois Institute of Technology**<br>*Role of Attribution in Global Food Surveillance* |
| 14:00 – 14:30 | *Break* |
| 14:30 – 16:00 | **Dr. Radford Davis, Iowa State University**<br>*Surveillance for Livestock Diseases that Impact Food Security and Food Safety* |
| 17:00 – 18:00 | *Reception* |
| 18:00 – 20:00 | *Dinner* |

**Wednesday, October 20**

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|---|---|
| 07:00 – 08:00 | *Breakfast* |

**Caucuses**

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|---|---|
| 08:00 – 09:30 | **Country sessions** |
| 09:30 – 12:00 | **Plenary session**<br>Dr. George Atkinson, moderator |
| 12:00 – 12:10 | **Closing remarks**<br>Dr. George Atkinson |
| 12:10 – 13:00 | *Lunch* |
| 13:00 | *Adjourn* |

# Early Warning: The Necessary Beginning**

Stephen S. Morse, Ph.D.
Professor, Department of Epidemiology, Columbia University
Director, PREDICT, USAID Emerging Pandemic Threats program

**Summary**

Although most infections have been with us for a long time, new infections enter the human population or rapidly spread from a geographically limited area. Infections that appear suddenly or rapidly increase in number of cases or geographic range, are often called "emerging infections." Examples include human immunodeficiency virus/acquired immunodeficiency syndrome (HIV/AIDS), SARS (Severe Acute Respiratory Syndrome), Nipah, and pandemic influenza (H1N1-2009). Early warning surveillance is essential if we wish to prevent currently existing infectious diseases from increasing their range, or to prevent the next pandemic. But we do not currently have adequate capabilities in place at virtually any level. While the scientific issues are complex, I believe we have the scientific framework to begin, and that recent technological/scientific advances make this an opportune time to attack this problem. Recommendations include: the need to develop capability both to identify (and rule out) common infectious diseases, as well as the unexpected or unusual; implementing the revised International Health Regulations; coordinating reporting systems and enhancing data sharing; encouraging interagency cooperation; maintaining personnel; strengthening research to refine microbial risk assessment and triggers for action, and continuing to educate policy makers on the importance of early warning surveillance.

**Current realities**

Since the middle of the last century we have witnessed the emergence of a number of "new" infections. HIV/AIDS is a prime example: unknown until the late 1970s. HIV has now become one of our greatest health concerns worldwide. Others include SARS in 2003, hemolytic uremic syndrome, pandemic influenza (H1N1-2009), and Nipah, as well as increases in Hantaan (hemorrhagic fever with renal syndrome) in Asia as a consequence of land use changes. Evidence suggests that the ancestor of HIV may have been introduced into the human population from another animal species (probably chimpanzees in central Africa), through hunting and butchering or handling of the meat. A similar pattern (entry into the human population through handling of food animals) was seen with SARS and H5N1 avian influenza.

Emerging infections thus often already exist in other species or in geographically limited human populations, but are given an opportunity to come in contact with new human populations – often as a result of agricultural or environmental changes. Important sources are therefore other vertebrate species, including wildlife. Changes in ecology and land use can result in the emergence of apparently "new" infectious diseases (this fact also emphasizes the value of the "One Health" approach, linking human and animal health, including wildlife). Infectious disease emergence is likely to rise with the increasing pace of ecological change and globalization continuing worldwide. While many of these infections may be geographically limited, or currently have limited ability to transmit in the human population (e.g., H5N1 avian influenza), others may be transmissible from person-to-person (such as pandemic influenza, SARS, and HIV), and may be spread through human activities such as global travel and trade, sexual transmission, the healthcare system or the blood supply, and many others.

Early warning surveillance is essential if we wish to prevent currently existing infectious diseases from increasing their range, or to prevent the next pandemic (whether of an already known infection, such as influenza, or the “next HIV”). However, the current reality is that we do not have adequate capabilities in place either for global surveillance of regionally or nationally important infectious diseases, or for new emerging infections. Capabilities tend to be fragmented and disease-specific, with foodborne disease surveillance additionally fragmented and often separate. The capability to identify, report, and differentiate both common and uncommon emerging infections is essential (Morse et al., 1996).

**Scientific opportunities and challenges**

Effective systems of surveillance and response will therefore be obligatory (Morse, 2007). Scientifically, we have unparalleled opportunities: a basic, if embryonic, scientific framework which can be built upon, and new capabilities that were unthinkable only a decade ago in communications, informatics, and diagnostic technology (Morse, 1995; Morse et al., 1996; Jones et al., 2008). When ProMED-mail was initiated (1994), there was no World Wide Web, and many colleagues in remote areas could get e-mail access only via satellite uplinks. Today, e-mail is widespread and almost half the world’s population has mobile phone access. This makes it far easier to report outbreaks, to develop networks for surveillance and data sharing, and enables more rapid collaborative research. In the response to the 2003 SARS outbreak, both epidemiologic data and basic research were shared rapidly through electronic networks, greatly accelerating the development of diagnostic tests and allowing effective public health response based on rapid case identification. The widening availability of mobile phone networks now extends this reach even further, making disease event reporting possible in the community and in the field, even in locales without healthcare or public health infrastructure. Similarly, advances in molecular technology have revolutionized diagnostic and identification capabilities (e.g., portable rapid molecular diagnostic tests, methods for genome sequencing of pathogens, and the computational power to compare these genomes and follow their geographic movement and evolution). The U.S. Agency for International Development (USAID) recently developed an “Emerging Pandemic Threats” program (which includes an early warning component, PREDICT), an excellent example of what can be done to begin developing global capacity in early warning and response.

Among the challenges, in addition to the need to develop and implement sustainable capacity, emerging infections remain a moving target. Environmental and ecological changes worldwide, and globalization, will increase both the opportunities for new infections to emerge and spread, and increase the complexity of the interactions. It is therefore essential to develop a deeper understanding of the drivers, or factors, of emergence (Morse, 1995), and how to prevent their unintended consequences. While we can identify many new microbes in other species, some of which have potential to become serious emerging infections, our ability to predict which infections are important and require special attention remains embryonic. Therefore, we also need to develop better scientific approaches for risk assessment and risk reduction. In short, we will require continuing development of our understanding of the drivers of emergence, and we must learn how to anticipate and avoid some of the currently unanticipated consequences of environmental changes and globalization.

**Policy issues**

Implementation and sustained political will remain the greatest challenges. I suggest the following as specific steps towards developing a more effective system:

- An effective system requires the ability to identify/rule out common infectious diseases, and to recognize and report the unexpected or unusual. Governments should support the development of networks with these capabilities, including laboratory capacity. To control costs, countries should pool resources and develop regional networks.

- More specifically, implementing the revised International Health Regulations (IHR) is a step toward enhancing global surveillance capabilities. Lessons learned from implementation should be used to improve the system.

- Coordinate reporting systems worldwide, and enhance data sharing (including ensuring compatible data standards). As many emerging infections are zoonotic, this should include sharing between human and animal health resources (consider the "One Health" framework, including joint teams and co-located facilities).

- Cooperation and coordination among the World Health Organization (WHO), Food and Agricultural Organization (FAO), and OIE (the World Organization for Animal Health), which has begun with avian influenza activities, should be extended and strengthened.

- Skilled personnel is key; resources should be provided to recruit and train sufficient high-quality personnel and to ensure a stable career path for these workers. Although (fortunately) pandemics and major emerging infectious disease outbreaks are rare, outbreaks of more common infectious diseases are sufficiently numerous to provide useful work in the periods between pandemics or major outbreaks.

- Educate clinicians, and also the general public, to recognize and report unusual outbreaks to appropriate authorities (in developing countries, where clinicians are in short supply, consider training local people to recognize and report.)

- Research to continue improvements in diagnostics and data collection should be strongly supported by appropriate technical and funding agencies.

- Refine microbial threat assessments and triggers for action. This is a nascent area; examples include definitions in the new IHR and discussions in USAID, CDC, and elsewhere. Technical and implementing agencies should strongly support continuing development of a useful risk assessment framework and defining triggers for action.

- To encourage sustained funding and political will, continue educating policy makers on the importance of early warning surveillance.

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**Table 1: Factors in infectious disease emergence**

| Factor | Examples of specific factors | Examples of diseases |
|---|---|---|
| Ecological changes (including those due to economic development and land use) | Agriculture; dams, changes in water ecosystems; deforestation/reforestation; flood/drought; famine; climate changes | Schistosomiasis (dams); Rift Valley fever (dams, irrigation); Argentine hemorrhagic fever (agriculture); Hantaan (Korean hemorrhagic fever) (agriculture); hantavirus pulmonary syndrome, southwestern US, 1993 (weather anomalies) |
| Human demographics, behavior | Societal events: Population growth and migration (movement from rural areas to cities); war or civil conflict; urban decay; sexual behavior; intravenous drug use; use of high-density facilities | Introduction of HIV; spread of dengue; spread of HIV and other sexually transmitted diseases |
| International travel and commerce | Worldwide movement of goods and people; air travel | "Airport" malaria; dissemination of mosquito vectors; ratborne hantaviruses; introduction of cholera into South America; dissemination of O139 V. cholerae |
| Technology and industry | Globalization of food supplies; changes in food processing and packaging; organ or tissue transplantation; drugs causing immunosuppression; widespread use of antibiotics | Hemolytic uremic syndrome (E. coli contamination of hamburger meat), bovine spongiform encephalopathy; transfusion-associated hepatitis (hepatitis B, C), opportunistic infections in immunosuppressed patients, Creutzfeldt-Jakob disease from contaminated batches of human growth hormone (medical technology) |
| Microbial adaptation and change | Microbial evolution, response to selection in environment | Antibiotic-resistant bacteria, "antigenic drift" in influenza virus |
| Breakdown in public health measures | Curtailment or reduction in prevention programs; inadequate sanitation and vector control measures | Resurgence of tuberculosis in the United States; cholera in refugee camps in Africa; resurgence of diphtheria in the former Soviet Union |

From: Morse, S.S. (1995). Factors in the emergence of infectious diseases. [CDC] *Emerging Infectious Diseases.* 1:7-15.

*** A policy position paper prepared for presentation at the conference on Emerging and Persistent Infectious Diseases (EPID): Focus on Surveillance convened by the Institute on Science for Global Policy (ISGP) Oct. 17-20, 2010, at Airlie Conference Center, Warrenton, Va.*

## Debate summary

**The following summary is based on notes recorded by the ISGP staff during the not-for-attribution debate of the policy position paper prepared by Prof. Stephen Morse (see above). Prof. Morse initiated the debate with a 5-minute statement of his views and then actively engaged the conference participants, including other authors, throughout the remainder of the 90-minute period. This Debate Summary represents the ISGP's best effort to accurately capture the comments offered and questions posed by all participants, as well as those responses made by Prof. Morse. Given the not-for-attribution format of the debate, the views comprising this summary do not necessarily represent the views of Prof. Morse, as evidenced by his policy position paper. Rather, it is, and should be read as, an overview of the areas of agreement and disagreement that emerged from all those participating in the critical debate.**

### Debate conclusions

- Strong support was expressed for enhancing global leadership and coordination for activities addressing infectious disease surveillance. To make this a reality, it is imperative that governmental agencies and international organizations significantly improve the coordination of their efforts.

- Capacity building for infectious disease surveillance was deemed essential, particularly with respect to strengthening laboratory capacity, epidemiological capacity, and regional networks.

- Scientific and public health communities must learn to better convey to government officials and the public the results emerging from the analyses of information obtained from infectious disease surveillance. Engaging the media is viewed as essential to communicating credible information that both supports government officials and fosters public trust by sharing relevant information that educates the citizenry.

- Rigorous analysis and modeling of surveillance data are fundamentally essential to formulate the type of information needed by policy makers, especially with respect to justifying the public resources devoted to disease surveillance.

- Country ownership with respect to infectious disease surveillance must be fostered through bottom-up approaches with links to regional networks to strengthen the sustainability of these programs and create more effective surveillance priorities.

- Political, economic, and technical barriers to sharing data from infectious disease surveillance across international borders should be significantly eased.

### Current realities

Prominent intergovernmental organizations (e.g., the United Nations [U.N.] and the World Health Organization [WHO]) are increasingly focused on infectious disease control worldwide through an array of programs, directives, and activities, such as the Millennium Development Goals, the WHO's International Health Regulations (IHR), and the Technical Area for Health Surveillance and Disease Prevention and Control of the Pan American Health Organization. Of central importance to many of these initiatives is the expansion and improvement of infectious disease surveillance. Yet, deficiencies remain in terms of effective coordination of roles and innovative leadership among domestic agencies, departments, and commissions, as well as between international organizations.

While wealthier nations maintain extensive laboratory facilities, epidemiological activities, and regional networks, less-wealthy regions of the world are often dramatically less well equipped in these arenas. This dichotomy is paradoxical, as less-wealthy areas possess a disproportionately strong need for these capabilities given that the global burden of infectious diseases is concentrated in these regions. Obviously, a scarcity of resources and myriad competing disease and health needs are the primary reasons that less-wealthy nations are deficient in these arenas.

Data transfer (i.e., the sharing of data across agencies and/or geographic boundaries) is increasingly recognized as playing an integral role in infectious disease control. The importance of data transfer has been highlighted for its role in prevention, accurately identifying outbreaks, and identifying resources for remediation. In addition, data sharing can mitigate the duplication of surveillance efforts that often occurs when different domestic agencies or national governments are not working in concert with one another.

A number of "new" diseases hass emerged since the middle of the last century, such as human immunodeficiency virus/acquired immunodeficiency syndrome (HIV/AIDS), human monkeypox, Severe Acute Respiratory Syndrome (SARS), and Lyme disease. The number of "new" diseases is expected to continue to increase due to the effects of ecological change and rapid globalization. Endemic infectious diseases are expected to remain problematic since it is difficult to control infectious diseases even when a cure is known. This is attributable to impediments such as the continued presence, and potential of transmission of, infectious diseases in animal reservoirs and vectors (e.g., *Salmonella* and malaria), the continued reservoir of disease in human populations (e.g., tuberculosis), and the influence of ongoing socioeconomic and political constraints. In line with this growth in the total number of infectious diseases ("new" and endemic), surveillance needs will expand in the short and long term.

Prevention is an important component of emerging and re-emerging infectious disease control, and early warning surveillance is integral to the success of any prevention program. Timely recognition of emerging infections is needed so that they may be promptly investigated and control plans outlined prior to large-scale outbreaks and/or pandemics. Prevention also relies on a thorough understanding of trends in incidence and distribution of known infectious agents — information that is a product of good surveillance data.

Even when surveillance data exists, it is not always acknowledged or used in a timely fashion. The history of HIV/AIDS provides a modern lesson on the importance of giving early attention to surveillance data. In the 1960s, a surge in opportunistic infections such as cryptococcal meningitis, Kaposi's sarcoma, tuberculosis, and specific forms of pneumonia was observed in parts of Africa. Although it is now known that this constellation of infections was directly related to HIV/AIDS, at the time the information was not viewed in a holistic manner that could have revealed the disease's emergence. Even when reports emerged of similar symptoms in other parts of the world (including clusters of warning signs in gay communities, which led to the initial name, Gay-Related Immune Deficiency (GRID), response was slow. It was not until the disease was better understood and outbreaks recognized that public health and political support for HIV/AIDS control fully mobilized. By that point, however, the disease had firmly taken root throughout the world and a global epidemic ensued.

## Scientific opportunities and challenges

The need for improved laboratory facilities and expanded epidemiological training and expertise in less-wealthy nations represents both infrastructural and scientific challenges to emerging and persistent infectious disease control. From an infrastructural standpoint, a need for improvements in terms of the coordination of resources, logistical capabilities, and policy processes was stressed. From a scientific perspective, technological advancements are likely to mitigate some infrastructural concerns over time, although this was generally viewed as a long-term endeavor that requires substantial research and investment.

Although the technology for rapid data transfer has markedly improved in the last decade, it was contended that significant progress in this area is needed. In addition, it was argued that important obstacles remain in terms of breaking down the political and economic barriers that impede data sharing. Political and economic issues that were raised as specific challenges included the publicly acceptable extent of individual privacy, country security, and conflicts regarding data ownership.

As technologies advance, new windows of opportunity for enhancing infectious disease surveillance emerge. This positive change was highlighted by examples of the potential value of infectious disease prediction based on the modeling of hotspots and infections.

Although early warning surveillance is widely recognized as a fundamental component of infectious disease prevention, many challenges remain. Monitoring must be consistent, comprehensive, and accurate for early warning to be effective. Moreover, new techniques are needed to help identify the early appearance of "new" diseases before they escalate within a population. However, early warning surveillance should not be considered a silver bullet for infectious disease control. Public health communities can never be fully prepared to prevent widespread transmission of infectious diseases because what is needed to avert a crisis is not always known in advance, particularly in the case of emerging diseases. However, given that early warning systems often provide critically important new information, they should not only continue to be used extensively, but research into how their effectiveness can be improved also needs to be expanded.

## Policy issues

There was general consensus on the need for significantly improving the quality of global leadership and coordination of disease surveillance designed to protect the public's health. However, there was clear disagreement on who should take the lead in improving agency coordination and in defining leadership responsibilities. While some touted the WHO as the primary choice for this role (citing improvements in the WHO's ability to act proactively rather than reactively), others argued that agencies like the WHO often talk about coordination without effectively improving it. In addition, coordination between international agencies was raised as a critical issue, especially with respect to the barriers impeding coordination caused by each organization's budgetary and political constraints. Candid dialogues among these international organizations concerning their funding and policy priorities were viewed as essential steps to any effective coordination on disease surveillance.

Capacity building for infectious disease surveillance was unanimously considered an essential need. Three fundamental areas for immediate amelioration were identified. The first was to expand and enhance laboratory capacity for disease confirmation (particularly in less-wealthy countries). The second focused on improving the national epidemiological capacity for better targeting where pathogens are located and to treat those who are directly affected. This can be accomplished in a variety of ways, such as through in-country training. The third recommendation was to create regional networks to increase coordination and cooperation among countries as well as to expand the opportunities for obtaining additional funding in resource-poor areas. These three recommendations were viewed as parts of a general, ongoing process that would take time to develop and implement.

There was also consensus on the critical need to improve infectious disease messaging to the public (i.e., enhancing the effectiveness with which both the scientific and public health communities convey accurate and timely information on the potential impact and/or risks of diseases). It was noted that although improvements have been observed in this arena, significant gains are urgently needed. There was agreement that the greatest challenge is the difficulty of communicating enough relevant information, including imparting an accurate understanding of the degree of uncertainty associated with almost all disease surveillance information. The apparent absence of public trust in the information provided by government agencies concerning the recent H1N1 outbreak was considered a prime example of the need for change in communication approaches.

It was noted that messages are undermined when risks are either overplayed or do not materialize, regardless of whether epidemics are mitigated through the appropriate interventions. Public confusion and even mistrust is created when the scientific and public health communities do not present uniform, readily understandable information. This situation often occurs when conflicting information is presented to the public. A common example involves the distribution of conflicting information based on the use of different models in the analysis of disease surveillance data. It was suggested that these communities work together to provide authenticated information to the public from the outset of a disease outbreak and to appropriately engage the credible media. It is critical that officials identify any incorrect or false information provided by unofficial sources (as was routinely witnessed in the 1990s) and educate the public concerning the real long-term risks from infectious diseases, even when crises are averted.

Discussions also noted that the value of disease surveillance data is practically realized only after rigorous analysis and interpretation using the appropriate modeling methods. From this perspective, data analysis and modeling were viewed as integral to obtaining the information required to effectively inform the policy-making process. These same results can be useful in identifying the societal benefits needed to justify the resources spent on disease surveillance itself.

It was strongly agreed that country ownership with respect to designing and implementing infectious disease surveillance programs should be fostered. A bottom-up approach was widely endorsed, with strong connections to regional networks. It was voiced that sustainability and effective agendas will be strengthened when less-wealthy countries take responsibility for their own health destinies. Within this context, it was asserted that less-wealthy countries should invest more of their own gross domestic products into disease surveillance and other actions needed to effectively respond to emerging and persistent infectious diseases. These investments would permit each country to set its own priorities rather than rely strictly on funds from donor organizations that come with preset goals, which may not be consistent with what a country wants or needs.

A vigorous debate focused on the need to resolve conflicts over the sharing of disease surveillance data among agencies, international organizations, and across international borders. The need for facilitating data sharing was supported by several examples, mostly involving the consequences of delays in transferring scientifically credible information to policy makers. In the case of the recent H1N1 epidemic, only two scientific papers were initially available on projecting the spread of the disease. It was argued that correcting this problem would involve a mindset shift for scientists who would have to sacrifice some assurance of accuracy (uncertainty of conclusions) in favor of expediency so that policy makers would have the information they need to make timely decisions.

In addition, it was noted that information sharing is greatly impeded by vastly different national, political, and economic concerns. Countries are frequently hesitant to share information because the perceived political and social risks outweigh the potential benefits. For example, countries may be concerned that the dissemination of their disease surveillance data will cause security breaches, especially with respect to the methods used to obtain that information. Similarly, they may fear economic fallout (e.g., reduced tourism or revenue losses caused by the dissemination of proprietary data). While no consensus was established on how much information should be shared across borders, it was agreed that significant improvements in how this information is shared are needed to make disease surveillance a viable tool to protect human health, both domestically and internationally.

Although it was agreed that surveillance data do not guarantee that prevention will be possible, it was emphasized that no system designed to protect human health can function properly without effective surveillance. Additionally, it was recommended that research be fostered with respect to developing new ways to improve disease tracking processes and to identify more precise applications of the data.

Support was raised for implementation of the revised International Health Regulations for emerging and persistent infectious disease surveillance objectives. This support was challenged by the argument that although the IHRs are important, they are not useful for early warning purposes.

Although much emphasis has been placed on the practice of surveillance for infectious diseases, specifically to ensure that monitoring obtains the appropriate data, there were those who stressed that the data gathering process is only the first step in surveillance. The data must also be analyzed and modeled in ways that properly inform the decision-making processes. From a policy perspective, infectious disease surveillance information must be distilled so that individuals in leadership positions can understand what the data mean and effectively use this knowledge to allocate financial and human resources appropriately.

While the rise of HIV/AIDS exemplifies the importance of practicing infectious disease surveillance and heeding the warning signs that surveillance provides, it was emphasized that surveillance data alone does not ensure that crises will be averted. With so much information collected and distributed, it is often difficult for researchers to effectively decipher what pieces are important and to predict which diseases will escalate. This abundance of information makes it especially challenging for policy makers to decide where their finite resources should be allocated. For many reasons, including politically motivated priorities, policy makers often wait until an infectious disease threat has fully materialized before responding. Discovering the best way to balance surveillance reports and competing social and political priorities is an obvious goal for all communities involved in disease surveillance.

# Emerging Infectious Diseases in the 21st Century: A Threat to Global Economic Security**

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**Summary**

There has been a dramatic global re-emergence of epidemic infectious diseases in the past 30 years. In 2010, infectious diseases are once again a leading cause of morbidity and mortality in the world. The reasons for this re-emergence are many, but the principal drivers are uncontrolled urbanization, which has greatly increased infectious disease transmission, combined with the massive movement of people, animals, and commodities via modern transportation into areas that do not have the public health infrastructure to detect and contain introduced pathogens. This provides the ideal recipe for increased epidemic transmission of both well known and novel pathogens. The potential for rapid spread of epidemic disease around the world is a new phenomenon that threatens global economic and public health security.

**Current realities**

Rare, unexpected plagues of epidemic infectious diseases have entered human history for centuries, with devastating consequences. After having effectively controlled most major infectious diseases in the mid-20th century, epidemic infectious diseases have returned with a vengeance. Moreover, the frequency of epidemics caused by newly emerging and re-emerging pathogens, and the likelihood of rapid global spread, have dramatically increased in the past three decades. This is illustrated by the emergence of pneumonic plague in India (1994), panzootic H5N1 influenza in Hong Kong (1997), Nipah encephalitis in Malaysia (1999), severe acute respiratory syndrome (SARS) in China (2003), and pandemic swine origin H1N1 influenza in Mexico (2009). A combination of global demographic, socioeconomic, environmental, and ecological trends have driven this dramatic re-emergence of epidemic infectious diseases in the past 30 years. These trends, along with continued globalization, are projected to continue for the indefinite future – making the world highly vulnerable to increased occurrences of epidemic infectious diseases that will threaten global economic security and public health.

The current reality is that few countries in the world, especially those resource-poor countries where most of these diseases will emerge in the future, have the laboratory and epidemiologic capacity and capability to address this threat. With few exceptions, most infectious pathogens are ignored until an epidemic occurs, at which time both local and international health agencies move into emergency response mode, which is almost always too little, and too late, to have any impact on transmission. This type of crisis mentality is very dangerous when dealing with highly transmissible pathogens that can move rapidly around the globe via modern transportation. Only two epidemics in modern history have shut down global commerce, both of them in the past 16 years. The first was the 1994 Indian epidemic of pneumonic plague, which was more an epidemic of panic than disease. The 2003 SARS epidemic was even more devastating, costing the global economy an estimated $60 billion to $100 billion (U.S.). Neither of these epidemics were major public health crises, but both threatened global economic and public health security by shutting down the airline network. Future epidemics, which will surely occur, will likely have an even greater economic impact. The 2009 H1N1 influenza pandemic had the potential to cause such chaos, as the virus was highly transmissible and spread around the world in just a few months. Fortunately, however, the illness associated with that virus was mild and did not cause the panic and alarm that a more virulent virus would have done. In summary, the current realities are that we are highly likely to see emerging infectious disease epidemics that threaten economic and public health security with increasing frequency in the next 20 years, but programs to prevent or decrease that threat are not being developed and effectively implemented.

**Scientific challenges and opportunities**

Challenges include: 1) To develop and implement proactive early warning disease detection systems that can detect, identify, and contain pathogens with epidemic potential before they spread too widely. It is projected by the United Nations (U.N.) that in the next 25 years most of the economic growth will be in Asia, which will drive increased population growth in the cities, caused primarily by a circular rural to urban migration of people from rural areas moving to the cities to seek work, but returning to their rural homes a few times a year to plant and harvest crops and visit family. This will increase the risk of exotic pathogens that have been infecting people for hundreds of years in rural areas being introduced into crowded Asian cities, where there is increased risk of epidemic transmission. The economic growth will also drive increased movement of people, animals, and commodities via modern transportation, which will increase the probability of rapid spread of pathogens to other parts of the world. 2) To prevent the spread of pathogens and arthropod vectors via modern transportation. This has important economic and political implications that have not been addressed by international health agencies. The main problem is the thousands of jet airplanes that move more than two billion people and hundreds of millions of animals of all kinds around the world annually. These people and animals are carrying infectious pathogens with them, increasing the probability of global spread. 3) To develop the political will and funding needed to support laboratory and epidemiologic capacity-building and technology transfer. This will require eliminating apathy among the public and policy makers. 4) The vast majority of emerging diseases will never have a drug, a vaccine, or therapeutic antibody that can be used for treatment and prevention. To effectively contain and prevent these diseases, we must study their ecology to better understand transmission dynamics.

Opportunities include: 1) Training scientists and transferring the latest technology to countries of the region. This will provide expertise and technology to develop a biomedical research base, leading to discovery of new drugs, vaccines, diagnostics, and other treatment modalities, thus providing an economic stimulus. 2) Developing better laboratory and epidemiologic capacity, and early warning disease detection systems, which will allow public health officials in countries where surveillance is implemented to better understand the etiology of the infectious illnesses in their countries. This will result in more effective containment, decreased transmission, and early treatment, thus saving lives, improving the overall public health, and increasing the productivity of the population in general. 3) Discovery of newly recognized pathogens will drive basic science research. This research activity will result in creation of new jobs and new commercial ventures.

**Policy issues**

Policy issues that must be dealt with to reverse the trend of globalization of epidemic infectious diseases include the following:

- The movement of pathogens and vectors via modern transportation. Dealing with this issue will have to be the responsibility of the World Health Organization (WHO), with backing from the World Health Assembly. Regulation and enforcement should be incorporated into the International Health Regulations.

- International cooperation and sharing of proactive surveillance data. This will require developing a secure network — using the latest information technology — to link local, country, regional and global health agencies in order to share real time specific data on disease incidence, **location**, and spread.

- Triggers to initiate local and international response to epidemic transmission. Emergency response plans are developed by public health officials, but implementation of the response depends on a political decision. Implementation triggers that are, to the extent possible, outside the political realm, must be built into the response plans to allow rapid and effective response.

- Developing regional surveillance and response programs as opposed to country programs. Effective control in one country is not possible if the rest of the countries in the region are experiencing high-level disease transmission. The WHO, in collaboration with the countries and international funding agencies, must develop and implement regional control programs.

- Capacity-building and technology transfer to improve early warning surveillance. Currently, clinical samples from an emerging pathogen must be sent to the U.S., Australia, or Europe for identification of the pathogen, resulting in valuable lost time in diagnosis. We need to build the capacity and transfer the technology to allow resource-poor countries — where the diseases are likely to emerge — to develop and implement active early warning disease detection systems sensitive enough to allow containment before the pathogen spreads too widely.

- Improved cooperation and coordination between human and animal health surveillance systems. The systems as currently managed run parallel to each other with little exchange of data. We need to develop collaborative field programs that are linked by the latest IT systems to share real-time data.

- Emphasis on prevention and containment as opposed to emergency response. We are a crisis-oriented society; we do not do anything to prevent most diseases, rather waiting until an epidemic occurs and then trying to respond. We need to emphasize preventive medicine more and stop putting all the emphasis on curative medicine.

- Responsibility of the private sector. We need to harness the private sector resources and expertise to help fund the types of programs that will prevent epidemics that threaten global economic security.

*** A policy position paper prepared for presentation at the conference on Emerging and Persistent Infectious Diseases (EPID): Focus on Surveillance convened by the Institute on Science for Global Policy (ISGP) Oct. 17-20, 2010, at Airlie Conference Center, Warrenton, Va.*

## Debate summary

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### Debate conclusions

- Developing drugs and vaccines for the majority of infectious diseases requires additional information that can only be provided by enhancing disease monitoring and laboratory-based surveillance.

- For those infectious diseases where no clear pathways for developing drugs or vaccines exist, public health prevention initiatives must be expanded (e.g., the use of mosquito nets for malaria).

- Public-private partnerships must be strengthened to stimulate drug/vaccine research into the control and treatment of infectious diseases that would not otherwise be considered economically feasible. The private sector's role in the surveillance and mitigation of infectious diseases should also be widened since its engagement not only increases the economic viability of how infectious diseases are addressed, but also provides lessons in efficiency.

- Recognition of the importance of animal-to-human transmission necessitates better coordination and integration of infectious disease surveillance involving animals and humans.

- In recognition of finite human and financial resources, it is increasingly important to consider the priorities used to determine how these resources are allocated to specific geographic regions. While Asia is expected to bear a comparably larger disease burden, resources focused on infectious diseases are currently concentrated in Africa.

- Given the critical role played by all forms of transportation (especially air travel) in the transmission of infectious diseases, monitoring the health of travelers is an important component in the design of sentinel surveillance systems. Serious concerns regarding publicly acceptable levels of privacy and pre- and post- travel screening (including the choice of screening technologies) are major issues.

- Responsible government officials need to be well informed by the credible scientific community. In turn, these officials are responsible for conveying accurate information concerning infectious diseases, including the relative risks, to the public. Communication skills among public officials and scientists must be significantly improved to facilitate both processes and thereby, to gain the public trust needed to implement effective disease control.

- A redistribution of responsibilities among international, national, and local authorities responsible for infectious disease surveillance is urgently needed. While local ownership of and responsibility for infectious disease surveillance should be emphasized, especially in less-wealthy countries, any redistribution of responsibilities must be balanced against the increasing concerns over biosovereignty.

- To create an effective surveillance system for the protection of the public's health, it is critical that infectious disease surveillance data be more effectively shared across national borders and throughout geographical regions.

**Current realities**

Although much attention has been devoted to drug and vaccine research, it is unlikely that drugs or vaccines will ever be produced for approximately 90 percent of the known pathogens. Two principal rationales have been cited as the causes of this disparity. First, the production of drugs and vaccines for the majority of infectious diseases is not economically profitable. Thus, there is little incentive for private research investment into drugs and vaccines for these pathogens. Second, from a microbiological perspective, not enough is known to support the production of drugs or vaccines for innumerable infectious diseases caused by novel pathogens (e.g., SARS).

The expansion of modern transportation systems in recent decades has dramatically accelerated the movement of people, animals, and commodities across borders. This amplified movement — particularly via air travel — has acted as an efficient conduit for the spread of foodborne, vectorborne, zoonotic, and other types of infectious diseases through the transfer of pathogens among people who historically have had only modest contact with one another.

Urbanization and migration (primarily from rural areas to cities, but also circular migration whereby individuals oscillate between the two geographies) are both increasing at rapid rates. The United Nations (U.N.) projects that 80 percent of urban growth between 2000 and 2030 is expected to occur throughout Africa and Asia, but in the same period much of the economic growth will be in Asia. These trends will further stimulate population growth in cities. This increases the risk of exotic pathogens from rural areas being introduced into crowded urban areas under conditions that promote epidemic transmission.

It was generally concluded, from both scientific and policy perspectives, that international organizations such as the U.N. and the World Health Organization (WHO) have been largely ineffectual in leading global surveillance efforts needed to combat these trends.

During the past two decades, funding and resources for emerging infectious disease control (including surveillance) have predominately been concentrated in Africa. Despite this substantial investment, emerging infectious diseases remain a debilitating problem on the African continent. Asia, by contrast, has received significantly less financial support although Asia bears a comparably larger infectious disease burden. Unique ecological factors found in Asia were cited as reasons that future infectious diseases are likely to originate on that continent, especially those of zoonotic origin. It was suggested that most future infectious diseases causing the rapid movement of epidemics and significantly impacting regional and global economies are therefore likely to originate in Asia and be caused by viruses of zoonotic origin.

In the past 20 years, funding for infectious disease control has not been uniform across all world sectors. Wealthier nations have proven to be the most extensive investors in this issue, with the majority of their fiscal resources diverted to their own local initiatives or to Africa.

Country ownership of surveillance initiatives (i.e., the country acting as the principal driving force behind surveillance in terms of its design, goals, and implementation) is highly unusual in less-wealthy countries. Support from wealthier countries frequently results in their control over the strategies and plans used to implement surveillance programs, often leading to initiatives that are not well suited to the needs of a specific locale. The balance between the influence of wealthy and less-wealthy countries must be re-evaluated to support effective disease surveillance. Currently, less-wealthy countries depend on funding provided by international agencies that are tied to a specific disease (e.g., malaria or HIV/AIDS). As a result, agencies outside the affected country set priorities that may or may not be consistent with the needs of the targeted communities.

It was repeatedly mentioned that the public health community's ability to effectively communicate convincing and cohesive messages to policy makers and the public is lacking. It was stressed that this deficiency not only undermines the public health community's efforts to convey important information, but also engenders mistrust among the public and impedes political support for infectious disease control efforts such as surveillance.

**Scientific opportunities and challenges**

The reality that approximately 90 percent of pathogens will never have a drug or vaccine to combat their impacts was noted as an increasingly significant issue; the appearance of outbreaks and epidemics is significantly increased when there are no pharmaceutical treatments in place. As a consequence, the challenge of controlling emerging and persistent infectious diseases is intensified and new ways to tackle the problem are needed.

Human surveillance and animal surveillance typically occur in isolation of one another. Yet, transmission of infectious diseases from animals (both wild and domestic) to humans (i.e., zoonoses) is considered to be a major and increasingly important problem. The process of establishing sustainable mechanisms to develop coordination between these two surveillance realms is an important challenge requiring immediate attention.

Globally, hundreds of infectious diseases have been identified. However, there are also an undetermined number of unidentified infectious diseases. This is illustrated by the identification of more than 30 previously unknown diseases and viruses in the past three decades. The emergence of new and previously unknown infectious diseases poses significant challenges in terms of the design and implementation of strategies for their identification and control. The development and deployment of new, broad-spectrum systems designed to provide the rapid genomic identification of diseases is critical to support modern surveillance systems. These systems can better facilitate the timely decisions needed to control outbreaks, prevent the spread of disease, determine the proper allocation of resources, and adjust disease control programs to effectively protect human health.

Although wealthier nations have developed reasonably strong surveillance capacities, the same is not true among less-wealthy nations. Two issues are of prime concern: the sustainability of surveillance programs and the breadth/quality of laboratory capacity. Both require focused attention in the near future.

The rapid spread of infectious diseases via modern modes of transportation creates logistical problems and raises questions within ethical spheres. Not only does the movement of people and pathogens within a globalizing world increase the probability of transmission and spread — a significant public health and economic challenge in and of itself — but it also is complicated by the logistical detection of disease at border crossings and raises many privacy concerns through practices such as airport screening. Ways to successfully combat these barriers are needed, but are complicated by economic concerns. For example, two recent epidemics (plague in 1994 and SARS in 2003) caused substantial interference to the global airline industry. This resulted in an enormous financial drain on the world economy.

**Policy issues**

The challenges created by the absence of drugs and vaccines for the majority of infectious diseases were highlighted as issues that require multiple, creative solutions. First, an expansion in the role of prevention and monitoring, including epidemiological studies, is needed to rapidly stem outbreaks via other traditional public health measures, such as hygiene and sanitation. In addition, the number of diseases that lack pharmaceutical interventions could potentially be reduced through more aggressive public-private partnerships. In particular, partnerships that increase research into drugs or vaccines for diseases that would otherwise not be considered by the private sector alone (due primarily to commercial concerns) are of great value.

Despite an enormous investment in funding infectious disease control within Africa during the past two decades, there was concern expressed over how effective these resources have been in controlling infectious diseases in general. There was considerable discussion of a proposal to allocate more resources for disease surveillance to Asia, even under circumstances that required diverting these types of resources away from Africa. A variety of explanations and reasons motivating changing the priorities for resources from Africa to Asia were given including: (i) the presence of confusing and disruptive political and economic pressures in Africa that have led to a poor return on investment of funds devoted to a given region, (ii) the increasingly rapid urbanization and economic growth in Asia that can be expected to cause significant increases in the outbreak and spread of infectious diseases in populated areas and the increased need to commit substantially larger resources to surveillance, containment, and control activities, and (iii) the prediction that most new diseases threatening the security of regional and global economies will originate in Asia and be caused largely by zoonotic viruses.

While the potential importance of these reasons was acknowledged and the value of increased investments in disease surveillance in Asia recognized, there was no consensus that shifting financial and human resources now devoted to disease surveillance in Africa to Asia could be supported. The principal reasoning opposing such an Africa-to-Asia shift centered on the widely recognized severity of the current and expected disease burden in Africa. There was strong support for increasing the overall resources to permit more to be sent to Asia while at least maintaining current levels in Africa.

The increased probability of spreading infectious diseases via modern transportation mechanisms raised complex issues. Nonetheless, it was generally agreed that properly controlling the impact of transportation on infectious disease spread must be addressed despite the potential introduction of significant social, political, and economic problems. Several potential solutions were suggested for managing the intersection of travel and spread of disease including: (i) sentinel surveillance systems in airports, (ii) prescreening prior to travel in high known-disease incidence countries, (iii) health monitoring as a follow-up in the destination country, (iv) widespread enforcement of the WHO International Health Regulations, and (v) expanded basic research into new approaches to monitoring the health of travelers during their journeys. Major concerns were expressed about the use of airport screening, which was deemed in some cases as an unacceptable infringement on personal liberties. It was unanimously concluded that experience had shown that temperature scans in airports were ineffective. In spite of specific concerns, there was consensus on the need to immediately implement a variety of new, practical measures to reconcile increased travel with obtaining accurate surveillance data.

One dissenting opinion focused on the view that travel did not increase infectious disease risk and that if travelers feel their access to transportation is threatened, they will withhold the information essential to accurate surveillance.

The public's distrust of scientific data and predictions, especially in conveying the degree of risk involved with infectious diseases, was universally cited as an enormous problem requiring decisive actions aimed at re-establishing the public's confidence in scientific reasoning. It was also collectively asserted that the scientific and public health communities must learn how to more effectively convey information within public, political, and media spheres without providing inappropriately conflicting information that confuses these sectors. Specific methods for achieving these goals were not evident. Disagreement was expressed concerning precisely what information, and therefore the degree of understanding, the public and policy makers want. Some saw great value in exploring what information the public would accept from health officials, while others felt that public health messaging should be based strictly on issues identified within the health communities, irrespective of public and political desires.

Considerable agreement was found concerning the role of local institutions in the ownership of strategies and programs used in the surveillance of emerging and persistent infectious diseases. While it was unanimously concluded that a more bottom-up development of a country's role in designing and implementing surveillance systems is needed to identify the priorities for data collection and to create sustainable surveillance systems, it was also noted that promoting the sharing of the resultant information is an essential part of the global value of the data.

Although country ownership was deemed critical, there were consistent calls for increased global leadership in infectious disease surveillance. Reasons for this were cited as: (i) the impact of a rapidly globalizing world, (ii) the need for regional networks, which require top-down guidance, (iii) the role of travel in infectious disease transmission, which displaces national agendas, (iv) and the importance of standardized information. While the need for global leadership was not disputed, no consensus was reached on which international body should take the lead in these matters (e.g., the U.N. versus the WHO) and there was concern over how to convince countries to work together through international organizations.

It was noted that the programs for disease surveillance in humans and animals are not well connected. The two systems generally run parallel to one another without much coordination or communication. While there was agreement that greater interface is needed between the two, the discussion concerning what practical solutions should be pursued reached no specific conclusions. There was clear agreement that the intersection of human and animal surveillance deserves a more extensive debate that focuses on specific next steps. Nonetheless, it was widely suggested that countries should adopt the "One Health" approach focused on greater information sharing between human and animal health experts, as well as cooperative efforts to identify and prevent infectious diseases that can cross species barriers.

While data collection is the natural focal point of surveillance, data exchanges and sharing — particularly across country borders — both remain significant obstacles that threaten coordinated infectious disease control. A second major barrier is the lack of laboratory support for surveillance. While there was general consensus that data should be more effectively and extensively shared, there was disagreement on how to better develop data exchanges and on how much data can and should be shared. Suggestions for improving this problem included: (i) fostering better linkages of surveillance systems through leveraging the Internet (e.g., systems such as ARBONET), (ii) enhancing the interoperability of data, and (iii) encouraging a mindset shift on data ownership issues among the countries involved in the initial surveillance. Unresolved barriers included privacy concerns, data ownership issues (e.g., political, security, and economic), and assurance of scientific accuracy.

Capacity building for infectious disease surveillance was considered an essential activity, and specific recommendations were made for amplified laboratory support (particularly in less-wealthy nations where laboratory networks are frequently subpar), increased epidemiological training and equipment support, and fostering regional networks. The development of internationally sustainable programs for all of these activities is essential as well. The major challenges were identified as those associated with the funding of surveillance systems, which should be fundamentally anticipatory but usually are reactionary. Without a crisis of international dimensions, it is difficult to establish and implement priorities for the reallocation of either financial or human resources toward disease surveillance.

Infectious diseases threaten commerce through channels such as impeding tourism, closing animal markets and therefore endangering food supplies, and restricting transportation for both humans and commodities. It would be mutually beneficial for the private sector to increase its role in infectious disease surveillance and control. It was widely agreed that global business communities are critical partners in addressing these issues and that an effort to bring these communities into the debate is critical. Public health and scientific communities need to join the private sector in publicly discussing and promoting cooperative efforts to combat infectious diseases, especially with respect to identifying specific roles for the private sector that are consistent with regulatory responsibilities. These public-private partnerships also can be anticipated to promote open discussions of disease risks that can bolster public trust in the subsequent decisions made during outbreaks and pandemics.

# The Transition from Pandemic Response to Pandemic Prevention**

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**Summary**

We live in an era of unprecedented threats from microbes. Various factors have conspired to make the global human population more susceptible than ever to pandemics with the potential to devastate health and economies. The speed and frequency of contemporary pandemics make the relatively slow and resource-intensive traditional public heath responses — such as the development of diagnostics, vaccines, and treatments — insufficient. Fortunately, a new wave of scientific research has revealed that far from random occurrences, pandemics share a number of features which make them amenable to prediction and prevention. A percentage of the global disease control portfolio must now be re-focused on the creation of a global pandemic immune system, aimed at seeking out novel infections in humans and animals before they spread regionally, identifying quickly and effectively the agents causing them, and sounding alarms which permit rapid response and containment weeks, months, and years earlier than current systems allow. Such systems will provide much-needed protection from both natural as well as artificial microbial threats, helping move global disease control toward a truly preventative science.

**Current realities**

The global population is increasingly vulnerable to pandemics that have the potential to devastate economies as well as health. Human incursion into regions of wildlife diversity and the increasing trade in global wildlife both cause an escalation of microbes jumping from animals to humans. Increased density of human populations provides critical "fuel," permitting such cross-species jumps to persist in human populations long enough to adapt and spread. For example, a 2004 serological survey of rural villagers exposed to primates found that 1 percent of the villagers had antibodies to simian foamy virus. Elsewhere, Africans who had reported contact with nonhuman primate blood were identified as serologically active for a wide array of primate T lymphotrophic viruses. High concentrations of domesticated animals also provide opportunities for the mixing of human and animal pathogens. This situation lends itself to the emergence of an incredible range of diversity in microbes — some with the potential to spread and cause disease (Pike et al., 2010). These issues are exacerbated by the recent explosion of air travel, which geographically connects disparate human populations who were once isolated into a massive population; thus, the probability that a localized outbreak (stemming from natural or man-made sources) will become a global pandemic is further amplified.

Fortunately, scientific techniques are now available to begin tackling the difficult task of predicting and preventing pandemics. Viral detection through RNA sequencing and polymerase chain reaction (PCR) has become increasingly accurate and sensitive. Less sample volume is required to yield robust results and increasingly smaller amounts of virus can be definitively identified. Advancements in molecular phylogeny allow for novel viruses to be recognized and for patterns of emergence to be determined. Importantly, information technology makes it possible to survey remote communities at the human-animal interface and share that data in a "real time" manner with coordinating centers around the world.

**Scientific challenges and opportunities**

Breakthroughs in the science of pandemic prevention over the past decade have shown that, far from isolated random occurrences, a set of processes underlies the birth of pandemics (Pike et al., 2010). Pandemics almost always emerge as the result of the movement of an animal microbe into the human population. While domestic animals can play vital intermediary roles in this process, the greater diversity of wild animal hosts and viruses provides the ultimate source of most human pandemics. Pandemics also arise disproportionately in certain geographic regions, with those areas of high biological diversity (including diverse wild animal hosts and their viruses) playing a central role. Additionally, pandemics are not evenly distributed among known groups of microbes. Certain pathogen classes, particularly those such as RNA viruses (which have high capacity to generate novel genetic diversity) represent more substantive threats.

While future scientific results will certainly increase our ability to predict pandemics, the existing body of information already provides concrete steps that can be taken to decrease pandemics. Monitoring the interface between humans and wild animals, along with the mediating influence of domestic animals, and working to decrease levels of exposure to animals, will increase the rate at which we identify and stop new pandemics. Current serological survey techniques allow monitoring schemes to be implemented in a variety of field settings. Such efforts need not be deployed indiscriminately, but can be focused on individuals with particular exposures to animals and in specific regions of the world. For example, this could involve systematic (perhaps every six months) sampling of blood from known bushmeat hunters in a hotspot such as Cameroon.

While information and laboratory tools have radically increased our ability to catch pandemics before they spread, access to these tools is not uniform across the globe. Breakthroughs in viral discovery techniques, including pathogen microarrays and direct sequencing, have dramatically increased our ability to identify novel pathogens. Yet such techniques remain limited by insufficient bioinformatics resources and have not yet been widely distributed to sites near viral hotspots. Increased communications infrastructure means that outbreaks may be more quickly identified, yet information technology must be improved and deployed to remote regions to take full advantage of the emerging viral detection technology. Upgrading technology infrastructure alone is not enough. An investment must be made in equipping laboratories and field stations in viral hotspots, and in training and maintaining a dedicated staff.

## Policy issues

The science of pandemic prevention has advanced to the point where specific, internationally directed policies have the potential to move global disease control from the current responsive posture to a future where pandemics are predicted and prevented.

- Regular and systematic disease surveillance, involving specimen collection and general health survey at the interface of human and animal populations, should be radically and systematically expanded to cover populations of hunters, market workers, and farmers in viral hotspots throughout the world. With the majority of emerging viruses being RNA viruses, monitoring could initially focus on this subset of viruses and then expand to monitor other viruses, bacteria and parasites.

- Viral discovery capacity should be improved through increased resources aimed at improving bioinformatics and expanding laboratory capacity to viral hotspots throughout the world. These resources should include the equipment and materials to test and analyze specimens and share the data worldwide, trained personnel to carry out the surveys and report the data, and general maintenance of sites positioned in viral hotspots.

- Infrastructure for communicating human outbreaks and animal die-offs rapidly from remote regions should be improved, coordinated and deployed in viral hotspots. This includes upgrading or introducing new Internet and phone capabilities, ensuring that the integrity of the system allows for reliable and consistent exchanges of information, and implementing appropriate low-tech alternatives where possible.

- Long-term disease baselines should be established in human and animal populations in viral hotspots and among other selected populations. This would require a complete serological survey of individuals in regular contact with wildlife in the regions of viral hotspots. After the baseline samples are taken, a biannual serologic survey of statistically significant portions of the populations would allow for the identification of novel viruses.

- Along with surveillance of humans at the human-animal interface, surveillance of wildlife such as non-human primates would help facilitate the prediction of which viruses will jump the species barrier. Obtaining samples from behavioral studies of wild populations or from wildlife relocation programs in preserves would allow for pathogen sampling of these populations.

- In addition to surveillance, behavioral modification campaigns should be implemented in areas with high human-animal contact. This strategy has been implemented in Sierra Leone to combat Lassa Fever and involves mapping, contacting relatives of infected individuals, prevention posters, songs by local musicians, and other outreach activities. Educational programs should also include “health hunter” sessions to teach proper handling of bushmeat.

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## Debate summary

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### Debate conclusions

- Efforts made in pursuing basic scientific research on infectious diseases and efforts to protect the public's health are distinct activities having different priorities, but mutually supportive goals. While their short-term priorities may differ, their overall contributions need to be integrated to achieve optimum benefits for protecting human health.

- While the value of active surveillance for increasing the lead time in identifying infectious disease outbreaks was acknowledged, its utility for improving the response of public health officials to such outbreaks was considered debatable. The appropriate utilization of surveillance information by policy makers was seen as a major barrier.

- Differing priorities of the many communities involved in the surveillance of infectious diseases routinely hinder the analysis of surveillance data and consequently, often result in a confusing characterization of the risk to the public.

- A standardized method or system of risk communication should be developed to aid in decision-making processes. Candid, ongoing evaluations of the strengths and limitations of these methods and systems need to be used to adapt to changing public needs and responses.

- The capabilities of each model for the analysis of surveillance data, including its strengths and limitations, need to be properly presented to policy makers. A systematic method for communicating the degree of public risk emerging from these models also needs to be developed to aid in the decision-making process.

- The expanding volume of data for the characterization of infectious diseases makes the analysis of that data the key factor in determining if it can be effectively used to inform public policy. Collecting and generating the scientific data is easier than appropriately utilizing it in the formulation and implementation of public policy.

- To ensure the optimal use of pathogen discovery as a public health tool, molecular biology data must be combined with epidemiological and behavioral data.

- The discovery of pathogens does not necessarily equate to identifying a disease of significant human impact for which a vaccine or other medical countermeasures will be needed.

**Current realities**

There is great need for the development of new methods to detect novel pathogens and, thereby, to protect the public from new disease outbreaks. In an age of increasing globalization and travel, pathogens can spread rapidly. Currently, there are more than 30 diseases spreading among communities worldwide that were not even known to exist just a few decades ago (e.g., HIV and SARS). Novel pathogens emerge, on average, every 16 months. Given that a large portion of novel diseases are zoonotic in nature, monitoring the animal/human interface is an essential component of any effective surveillance system designed to predict the onset of epidemics or pandemics from novel pathogens.

Wider use of currently available scientific techniques can strengthen current pandemic prevention efforts. Viral detection has become increasingly accurate and sensitive. Smaller sample volumes are required to yield robust results and increasingly smaller amounts of a virus can be definitively identified. Advancements in molecular phylogeny allow for many novel viruses to be recognized. However, while these technologies facilitate the detection of novel viral pathogens, they do not yet indicate which pathogens will cause disease in humans, which pathogens will jump from animals to humans (i.e., zoonotic diseases) and start circulating in humans, and which will cause a pandemic.

The ability of current surveillance systems to predict a pandemic is unclear. It is also unclear whether the novel approach to viral surveillance using ribonucleic acid (RNA) sequencing and polymerase chain reaction (PCR) would be able to improve the impact of disease surveillance for pandemic prevention. While an increasing amount of data is being generated, uncertainty remains as to whether present analysis methods are useful in pandemic prediction. The nature of viral behavior may not conform to a well recognized model and more research is needed to develop a robust method for determining which new virus(es) will cause a pandemic.

There was considerable debate regarding the difference between basic research results and the decisions and practices used to protect the public's health. A consensus was reached that basic research on infectious diseases and public health activities are not equivalent, but should be coordinated to produce the best results. These two activities may inform one another, and basic research can provide important epidemiological and biosurveillance information.

**Scientific opportunities and challenges**

While the value of active surveillance for increasing the lead time in identifying infectious disease outbreaks was acknowledged, its utility for improving the response of public health officials to such outbreaks was considered debatable.

While molecular techniques and scientific technologies have made significant advances in the area of viral detection, those advances have not translated into an increased capacity to predict which novel virus will be pathogenic, or which novel virus will jump the species barrier from animals into humans. There was consensus that the volume of data generated will continue to increase through efforts such as novel virus detection. For these data to be useful for decision-making, the analysis methods must also continue to evolve in the direction of producing clear and concise conclusions.

Even though the scientific methodologies designed to detect novel pathogens are increasingly accurate, and therefore more useful in the predictive models used for infectious diseases, the epidemiological data are often either not available or as well developed.

Consensus was reached surrounding the need for a complete baseline picture of a disease. An accurate baseline of what pathogens are in a community, when and how they appear, and the extent of their intrusion would allow for the detection of unusual events that could signal the emergence of a novel pathogen.

Advancement of scientific technologies has progressed rapidly in wealthy regions of the world, but that advancement has not been effectively transferred to less-wealthy areas, where even basic technology can be routinely unavailable. Consensus was expressed that capacity building in less-wealthy countries is a significant challenge that needs to be addressed, especially given that novel pathogens are most commonly found in these countries. Within the realm of capacity building, it was widely agreed that increased laboratory capacity is also essential to the success of surveillance and, accordingly, to the effectiveness of pandemic prediction. The strengthening and, in many cases, the creation of regional networks also were widely seen as critical to the building of in-country capacity needed to improve surveillance for novel pathogens.

A tangential discussion took place regarding the appropriate actions to be taken once a potential pandemic is identified. Current knowledge allows a vaccine to be created quickly for select diseases, such as influenza, once the genetic signature of a pathogen is known. There are several challenges to the development and implementation of intervention methods, such as identifying the safety of such a vaccine. Dissenting opinions were expressed concerning the requirements to prove vaccine safety and how those requirements should be viewed in light of a potential pandemic. The challenge of vaccine safety was considered to be intertwined with the challenge of the efficacy of a vaccine that could be used as a potential agent to combat a pandemic. It was pointed out that even if safety concerns were removed, data from novel pathogen surveillance in animals might not be directly applicable to humans. This is because the strain of the pathogen circulating in animals could be different from the strain of pathogen that would cause a pandemic in humans. More in-depth research is needed to resolve these issues associated with zoonoses.

Overall, a consensus was reached that while infectious disease data collection will continue to grow, primarily due to expanding scientific capabilities, methods for analysis and accurate risk communication are needed for optimal utilization of that data within decision-making processes. The expansion of data collection should be developed in ways that include laboratory capacity building for those areas that lack appropriate technological resources. The capabilities of each model for the analysis of surveillance data, including its strengths and limitations, need to be properly presented to policy makers. A systematic method or system for communicating the degree of public risk emerging from these models also needs to be developed to aid in the decision-making process. Candid, ongoing evaluations of the strengths and limitations of these methods and systems must also be put in place to adapt to changing public needs and responses.

### Policy issues

The absence of effective risk communication to policy makers and the public was the major policy theme identified. As a whole, emphasis was placed on the importance of conveying the degree of uncertainty in the analysis of surveillance data as an inherent factor in any scheme of infectious disease pandemic prediction. Public health officials and scientists should determine effective ways to communicate that uncertainty to decision makers. The development of methodologies to assess risk and to communicate risk accurately would aid in this effort.

There was agreement regarding the need to determine which actions would be implemented upon discovery of a novel pathogen. The policy implications of using preventive vaccinations are complex and need to be addressed comprehensively in a proactive, anticipatory way by multiple governmental agencies. The question was raised as to which organization (e.g., the WHO) should take on the primary leadership role in deciding which strain of influenza virus should be used in the development of a vaccine for pandemic influenza and how to practically proceed with the vaccine development in an economically rational way. It was noted that the rapid development of vaccines can occur only for known and well-characterized pathogens. It is unlikely that effective vaccines can be obtained in time to control a pandemic associated with a novel pathogen. Analogously, the question of which organizations should decide which vaccines should be made for diseases other than influenza was also voiced. The conflicting views expressed clearly identified this question as an important issue to be resolved through negotiation among the various national and international organizations.

Although there was consensus on the need to develop population-based infectious disease baselines, the personal rights of the individuals required for those surveys were seen as a policy issue to be resolved. To what extent an individual's civil rights and freedoms have to be balanced with the public health needs of the global community has yet to be determined.

The need for measurable indicators of success was often stated. Preventing an infectious disease outbreak is a success, but one that is difficult to gauge and rarely recognized by the public at large. Metrics to evaluate programs and demonstrate achievement are essential to aid both the public health community and policy makers.

# Novel Surveillance Systems: Good Value for the Money Spent?**

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**Summary**

"Syndromic surveillance" (surveillance for clinical syndromes without or before a definitive diagnosis can be or is made) as established and being utilized in various locations in the United States since 2001 to facilitate earlier detection and/or more targeted responses to outbreaks of disease is of unproven benefit. It is time to subject syndromic surveillance to rigorous evaluation to determine whether it provides benefits to public health or national security. if its benefits to public health and society cannot be documented, the federal resources currently devoted to it should be redirected to other disease surveillance approaches of proven worth.

**Current realities**

As is well known to the public health community, the tragic events of September 2001, led to an enormous infusion of (largely federal) funds to support implementation of and research concerning novel methods of disease surveillance in the U.S., in addition to monitoring of environmental samples for detection of microbial agents posing a threat to human health. These novel methods of disease surveillance, often collectively referred to as "syndromic surveillance," typically involve monitoring the frequency of one or more illnesses with a specified set of clinical features, such as diarrhea or signs and symptoms of respiratory tract infections in a population defined either geographically; by membership in a group like a health maintenance organization or the military, or perhaps simply by choice of health care provider. Not only have such systems been put into place in many locations and settings, but investigators at numerous academic and research institutions have established entire research programs dedicated to examining how well such systems do or might perform, especially with regard to "signal detection," (i.e., the identification of outbreaks, whether naturally-occurring or produced intentionally). One might go so far as to say that a "syndromic surveillance" industry has been spawned, including academic journals and annual scientific meetings dedicated in whole or in large part to the study of "syndromic surveillance" in its various forms.

There has never been serious reason to doubt that, once certain statistical parameters have been stipulated, even a fairly rudimentary surveillance system could detect time-space clusters of illnesses of sufficient size. However, the practical utility of such systems in the "real world" of public health has been questioned (Reingold, 2003). While much of the impetus to develop and continue to fund such systems derived from a concern about bioterrorist events, such as the intentional release of *B. anthracis* spores in the U.S. in 2001, even the most ardent supporters of "syndromic surveillance" generally have conceded that such systems could not have detected that event. Many experts also acknowledge that such systems are unlikely to prove their worth through the earlier detection of some future bioterrorist event, if it ever occurs. As a result, much (perhaps all) of the value of such systems is generally purported to rest on the more rapid identification and/or characterization of naturally-occurring outbreaks of disease, so as to allow or facilitate either more rapid or better-targeted responses and presumably yield reductions in morbidity and/or mortality. However, in the "real world" of public health, all or virtually all outbreaks of any significance are detected through existing, disease-specific surveillance systems and/or reporting by astute clinicians or laboratorians, and it is very unlikely that syndromic surveillance will detect important outbreaks that would otherwise go undetected. Earlier detection of some outbreaks, while possible, will rarely lead to reduced morbidity or mortality, because useful interventions either do not exist or will still arrive too late. And, the substantial burden of the work required to follow-up on “signals” (i.e., possible increases in the incidence of a given syndrome in a given population during a given time period) and determine both the significance of the “signal” and its cause invariably falls on already overworked and understaffed public health agencies.

There is experience using “syndromic surveillance” to detect and facilitate the prompt response to epidemics of influenza, meningococcal meningitis, and other illnesses that substantially predates the events of 2001. However, the infusion of substantial resources into the development and evaluation of such systems, as well as into theoretical research (e.g., computer simulations that “inject” an artificial “event” into a real or manufactured database) concerning the likely performance characteristics of such systems has led to an outpouring of papers and presentations over the past six to eight years, particularly in the U.S. and, to a lesser extent, in other developed countries.

These same nations have also begun to make substantial resources available to improve disease surveillance and outbreak detection capabilities in selected developing countries. The motivations for improving disease monitoring in developing countries include the recognition that many new, “emerging” infectious diseases are zoonotic in origin and originate in Africa, Southeast Asia, and South America. However, the challenges and costs of implementing and sustaining disease surveillance activities in developing countries are substantial, and the utility of “syndromic surveillance” and other novel surveillance modalities in such settings also remains unproven.

**Scientific opportunities and challenges**

Given the very substantial financial resources invested in the implementation of and research concerning “syndromic surveillance,” I believe it would be timely and appropriate to conduct a comprehensive review of what these systems have accomplished and whether these resources might profitably be redirected in the future toward strengthening other, more mundane forms of disease surveillance in the U.S. One example of an alternative use of such funds to strengthen disease surveillance in the U.S. comes from the network of Emerging Infections Programs (EIPs) funded by the U.S. Centers for Disease Control and Prevention (CDC) since 1995. (Editor’s note: The author has been the director of the California EIP site since its inception in 1995).

Originally comprised of two sites in the U.S., the EIP network currently includes 10 sites with approximately 44 million people under surveillance, although the number varies by disease for which surveillance is conducted. The EIP network conducts enhanced, population-based surveillance for a variety of foodborne infections (FoodNet), invasive infections caused by selected bacterial pathogens (ABCs), influenza, and other high-priority infectious diseases. Specially hired, dedicated staff conduct surveillance using a common protocol, including collection of bacterial and viral specimens as well as periodic laboratory audits to ensure the accuracy of laboratory-confirmed cases.

The surveillance system also provides the infrastructure underpinning a wide variety of analytic epidemiologic and laboratory studies of diverse infectious diseases. To date, the EIP has produced more than 500 publications concerning the various diseases under surveillance, many of them landmark studies. The EIP network, with the supplemental federal funds provided to it by CDC (at a cost of approximately $500,000 per million people under surveillance), is able to conduct disease surveillance of a quality, completeness, and consistency not generally attainable by state and local health departments that must rely solely on state and local funding, especially given the extent to which such funding rises and falls with economic conditions.

An alternative use of federal funds currently used to support "syndromic surveillance" implementation and research would be to finance a national system of disease surveillance based on the EIP model that has assured funding and that uses a common set of protocols to assure consistent, complete, and timely disease reporting. Given that disease surveillance in the U.S. is a state and local, rather than a federal mandate, such a system might be based on the federal highway system — with states having to adhere to federally established protocols, including those for data collection, storage and transmission, as well as identifier-free data-sharing with the CDC, to receive federal funds.

**Policy issues**

- Unless "syndromic surveillance" can be shown to produce good value for the money spent, an alternative use of federal funds to support enhanced disease surveillance activities in the U.S. and elsewhere should be given serious consideration.

- Federal agencies that provide financial support to "syndromic surveillance" activities in the U.S. should rigorously assess the concrete outputs of such activities with regard to outbreaks detected; morbidity and mortality averted, and other purported benefits.

- An alternative use of federal funds for disease surveillance would be to implement a national system modeled after the existing Emerging Infections Programs funded by CDC. Similar to the national highway system, this national surveillance system would be paid for by the federal government, but implemented by the state and territorial agencies with the legal responsibility to conduct disease surveillance, using methods, data collection instruments, and case definitions set forth by the CDC, after consultation with state and territorial agency partners.

- Internationally, similarly rigorous evaluations of the utility of various approaches to disease surveillance must be conducted, and the World Health Organization funded and empowered to oversee and coordinate such efforts.

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*** A policy position paper prepared for presentation at the conference on Emerging and Persistent Infectious Diseases (EPID): Focus on Surveillance convened by the Institute on Science for Global Policy (ISGP) Oct. 17-20, 2010, at Airlie Conference Center, Warrenton, Va.*

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### Debate conclusions

- The definition, utility, and value of syndromic surveillance all remain under debate. The usefulness of syndromic surveillance in designing effective treatments for infectious disease outbreaks was recognized, especially if syndromic information is combined with other data such as laboratory diagnostics. The effectiveness of data from syndromic surveillance as a separate tool for early warning remains controversial.

- Extensive, but not conclusive, discussion focused on the priorities with which resources are allocated to syndromic surveillance relative to other approaches used for surveillance of infectious diseases. Significant disagreement was expressed over the current importance of syndromic data in helping to shape public policy on identifying and controlling infectious diseases, and accordingly little support was expressed for reducing current resources allocated to syndromic surveillance.

- The value of syndromic surveillance as a deterrent against potential terrorist activities related to infectious diseases was noted.

- Historically, emerging diseases have been recognized by individuals noticing health conditions that differ from those ordinarily encountered. The rapid expansion of information technology has made it feasible to routinely share large amounts of information concerning the general health of communities, which therefore facilitates recognition of unusual events.

### Current realities

From the outset of the discussion, attention was focused on whether syndromic surveillance has much practical utility for early warning with respect to infectious diseases. The question of whether there is an adequate return on the current financial and human investments allocated to syndromic surveillance was also raised. The relevance of these questions to more and less-wealthy countries was an important part of the discussion.

Although syndromic surveillance was initially emphasized as a biodefense measure after the 2001 anthrax attacks in the United States, there was little support for the conclusion that this type of surveillance would have detected those attacks. Nor was there support for the value of syndromic surveillance as a predictor for almost any of the instances of bioterrorism in recent history in the U.S. There was considerable discussion concerning the assertion that the U.S. federal government needs to re-evaluate the role of syndromic surveillance and redirect its syndromic surveillance funding elsewhere. Such a decision in the U.S. would likely have a direct influence on the role of and support for syndromic surveillance worldwide.

There was consensus that syndromic surveillance is not the optimal surveillance system. However, many challenged the assertion that syndromic surveillance has no public health value and that funds should be directed elsewhere. Instances where syndromic surveillance proved to be useful were cited. For example, it was noted that syndromic data were used to provide a clinical definition of smallpox during the smallpox eradication effort, a definition that replaced laboratory confirmation as a method for identifying cases. In addition, it was asserted that the initial detection of SARS involved data on the symptoms of patients (i.e., syndromic surveillance) that facilitated global recognition of the disease at an early stage. It was conceded that syndromic surveillance was useful in the general context of surveillance for some specific diseases with well-defined intervention programs. For example, syndromic surveillance for acute flaccid paralysis was recognized as an effective method to identify probable polio cases. However, there are other diseases, such as malaria, for which syndromic surveillance is not effective. Syndromic surveillance using fever has not produced accurate or reliable information about malaria.

There was also agreement that syndromic surveillance has potential benefits in less-wealthy countries, where resources to conduct infectious disease surveillance through laboratory confirmation are generally not available. In those settings, syndromic surveillance can establish baselines against which the presence of disease outbreaks can be measured and thereby serve as a stop-gap method until adequate laboratory and epidemiologic capacity can be established.

In light of the varying uses for syndromic surveillance, consensus was reached that the benefit of this surveillance method should be evaluated on a case-by-case basis. Specific situations and circumstances exist where syndromic surveillance would have public health benefits that are commensurate with the costs involved. However, when more thorough, laboratory-based surveillance methods are available, syndromic surveillance may not provide the best investment of funding. There was some agreement that many millions of dollars are currently spent annually on syndromic surveillance in the U.S., although no specific number was confirmed.

**Scientific opportunities and challenges**

After extensive discussion, there remained questions about what constitutes a working definition for syndromic surveillance. The absence of a widely accepted definition was viewed as a barrier to determining how effective its role can be in surveillance systems. Myriad examples of syndromic surveillance were provided, including looking at newspaper reports, Web search queries, and recording malaria cases via public cell phones. There was agreement that a widely accepted definition for syndromic surveillance would help avoid confusion and misunderstanding about its value in disease surveillance.

Scientific capabilities and information technology have progressed so rapidly that there is now a voluminous amount of data covering a wide range of information that can be considered syndromic surveillance. While technological advancements are likely to keep moving forward, the challenge becomes how to accurately analyze this increasingly diverse information in ways that make it valuable to the decision maker. It was noted that syndromic surveillance itself can be viewed as its own new technology and that with time and experience, it may mature into an inexpensive and useful surveillance technique that stands alone. This point was questioned by refocusing on whether having more and more data enhances understanding or merely complicates the challenges of analysis (i.e., can the most important data be found when the amount of data continues to increase rapidly?).

Even where syndromic surveillance is successful in identifying outbreaks, concern was expressed regarding whether this information alone would translate into effective preventive action. The example of influenza was used to illustrate that earlier notification of an influenza outbreak solely from syndromic data did not lead health agencies to begin activities that would have shortened the influenza epidemic. Counter to this argument were many comments describing the benefits of advanced notice of an outbreak to target vaccination efforts and increase public health messaging in affected areas. These latter activities could have a significant positive effect on controlling, or at least lessening, the impact of an influenza outbreak.

Although the value of syndromic surveillance for advanced warning of epidemics due to known pathogens remains unclear, there was consensus that the current syndromic methodologies would not be useful in identifying diseases associated with unknown pathogens. Historically, a new pathogen has been identified by an individual noticing something out of the ordinary from the normal health patterns. However, it was noted that syndromic surveillance could be a valuable tool for systematically capturing and recording unusual events that are often used to characterize the health of a community at a central location. This background information derived from syndromic surveillance can be valuable in recognizing disease outbreaks and properly analyzing their potential impact.

**Policy issues**

Even in the event that syndromic surveillance could be systematically defined and more widely accepted as a viable surveillance option for public health, the need for thorough evaluations and analyses of a surveillance system including syndromic methods would still exist. There was consensus that syndromic surveillance data alone likely would not be adequate to mobilize significant actions by policy makers who seek to combat a potential infectious disease outbreak. The identification of additional information concerning public health in general may provide a broader understanding of the presence and intensity of infectious diseases as part of an overarching surveillance system. In these cases, syndromic surveillance data can serve as a supplementary data source that can be useful to policy makers.

The policy issue concerning whether large amounts of funding should be allocated to syndromic surveillance, given its limited value to public health, remained controversial. It was generally agreed that syndromic surveillance data had limited public health applications and that policy makers should be aware of the limitations of this form of surveillance and be cautious about how this information is used in initiating specific actions. It was advocated that syndromic surveillance data be used in settings where a specific disease is targeted and where specific intervention activities are being considered, especially when little other data are available. Complete re-evaluation of syndromic surveillance programs in general and how public resources are being allocated is a worthy activity, but any reallocation of support away from syndromic surveillance needs to be carefully considered in terms of how effective alternative options can be in providing more reliable information.

Much discussion centered on the need to supplement syndromic surveillance with confirming data from laboratory analysis. This was seen as a challenge for countries with weak laboratory capacity. Although there was agreement on the need to increase laboratory capacity in developing countries to improve all surveillance efforts, including syndromic, there was little agreement on specific ways to proceed except with respect to providing more funding. There was overwhelming support for increased funding for laboratory capacity building in less-wealthy countries. It was agreed that optimal surveillance techniques for the investigation of infectious disease outbreaks require laboratory confirmation of diagnosis, and that such confirmation requires adequate laboratory capacity in terms of both equipment and personnel. The major obstacle for an increase in capacity was determined to be the lack of a dedicated funding stream to improve laboratories around the world.

The role of the World Health Organization (WHO) in evaluating surveillance was vigorously debated. The recommendation that the WHO be funded and empowered to engage in systematic and complete evaluations of international disease surveillance systems, including syndromic surveillance systems, was only partially supported. In this proposal, the WHO would have both advisory and coordinating roles in such evaluations. Serious concerns were raised over whether the current WHO structure is appropriate to perform these evaluations.

The interests of policy communities in the data obtained through syndromic surveillance can be different from the interests of the public health community.  Although biodefense syndromic surveillance programs do not normally provide direct public health benefits, they can serve as a deterrent against those who would consider an attack on the public.  Thus, syndromic surveillance can have multiple benefits that span the interests of both the public health and national security communities.

# Integrating Climate Information into Surveillance Systems for Infectious Diseases: New Opportunities for Improved Public Health Outcomes in a Changing Climate**

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**Summary**

Many infectious diseases are climate-sensitive: climate acting as an important driver of spatial and seasonal patterns, year-to-year variations (including epidemics), and longer-term trends. Although climate is only one of the many drivers of infectious diseases, public health policy makers and practitioners are increasingly concerned about the potential impact of climate change on the health of populations. Noticeable changes in average climate are already being observed (and are therefore likely to affect the spatial distribution of some diseases, such as malaria). It is also expected that extreme events that can have devastating socioeconomic, environmental, and health impacts (e.g., floods, droughts, and heat waves) are more likely to occur.

The global health system is in a period of rapid change, with global health surveillance receiving increasing recognition as a primary source of protection from newly emerging and re-emerging threats: infectious diseases, new cycles of pandemics, bioterrorism, as well as climate change. Here we propose the incorporation of climate information into routine epidemiological surveillance systems for climate-sensitive diseases. To achieve this requires new and innovative mechanisms for strengthening observations, data management and sharing, development of relevant climate services, intersectoral collaboration, training and capacity building; all within an enabling policy environment. Our premise is that improved management of health risks associated with climate variability (such as the heat early warning systems recently established in Europe and North America) increases adaptive capacity of the public health sector to longer-term climate change. Specifically, we propose that the epidemiological surveillance community: (1) Establish collaborative partnerships with climate/environmental research and service communities to overcome policy and institutional barriers and identify opportunities for the effective use of climate information in health policy and decision-making; (2) Build the capacity of health professionals to understand, use and demand appropriate climate information/environmental information through creation of nested training opportunities in epidemiology and related professional training; (3) Support the research and development of appropriate evidence-based climate/environment products and services for use in health policy and decision-making; and (4) Support national and global investments in routine observation of climate, environmental and health phenomena pertinent to decision-making for climate-sensitive diseases.

## Current realities

We live in an increasingly interconnected world. The 2003 SARS outbreak demonstrated the economic impact of not having an effective global public health surveillance system in place. The rapidly increasing movement of people, pathogens, vectors, food, goods, and capital, much of it driven by cross-border and intercontinental decision-making that characterizes globalization — together with global environmental and demographic trends — has changed the global public health landscape. Consequently, new regulations (e.g., the International Health Regulations) and new public health actors emerged. For example, in 2005, China rapidly began to expand its surveillance and response capacity through its Field Epidemiology Training Program (FETP), while Brazil, Argentina, and Eritrea chose to use World Bank loans to develop national surveillance capacity. In addition, support for the Millennium Development Goals (MDGs) and related international health priorities focused on the poor, have meant increasing donor support for infectious disease surveillance in endemic countries. For example, in the last five years the U.S. President's Malaria Initiative spent $1.25 billion (U.S.) on malaria control in 15 African countries and the U.S. Agency for International Development (USAID) redesigned its surveillance strategy to focus on the use of data to improve public health interventions.

Preoccupied by these new concerns, some in the global health surveillance community have seen the rise of climate change on the political agenda as a detractor from achieving well-defined health objectives. Only recently has the community accepted the importance of climate change as an additional, potentially overwhelming, contributor to the global health burden. In 2008, the World Health Assembly recognized climate change as one of the defining challenges of the 21st century, and protecting health from its impacts is a priority for the public health community.

Climate-related health impacts are especially pronounced in poor communities, primarily in developing countries, where vulnerable people lack the basic infrastructure to cope with climate variability and change. In these countries, the livelihoods of millions of people are heavily dependent on rain-fed agriculture and seasonal water resources. These communities also bear the greatest burden of infectious diseases and disasters and have the least access to public health services. The devastation caused by Hurricane Katrina demonstrates that poor communities in wealthy countries are also particularly vulnerable to climate-related disasters. We observe that the voices of those most likely to suffer the ill health effects of climate change are rarely heard in international negotiations; the health consequences of climate variability and change are thus inextricably linked to global development choices, including issues of equity.

**Scientific opportunities and challenges**

Current approaches to incorporating climate into health planning and surveillance within climate change adaptation strategies are limited. Where found, they are often based on climate change scenarios developed from global climate models which focus on the long-term, commonly extending out to 2080 and beyond. We contend that, used alone, they are not appropriate for national adaptation policies for infectious disease prevention and control, as policy time horizons for the latter are much shorter (see Figure 1). We are concerned that a scientific area in its infancy is moving into public policy before appropriate tools, institutional arrangements, or best practices have been established. Most significantly, the science is entering public health policy making before public health actors are adequately trained to incorporate the new scientific understanding of climate variability and change into practical public policies and practices.

Climate is one of many drivers (e.g., social, political, economic, environmental, and technological factors) of infectious disease outcomes that is measured outside of the health sector. What makes it unique is the fact that it is measured systematically at a local and global scale using standardized methodologies, and its fundamental characteristics mean that it is ideally suited as an additional source of information in climate-sensitive infectious disease surveillance and forecasting. These characteristics include climatology, seasonality, diurnal rhythm, as well as predictability at multiple timescales (weather, season, decadal and climate change).

New opportunities exist for better management of climate-related health risks. These are made available through advances in climate science (e.g., predictability of El Niño events), satellite-based environmental monitoring technologies (e.g., routine information on the state of the environment provided globally, free of charge, from the MODIS satellite sensor), rapidly advancing communication technologies (impacting on data and knowledge sharing), and a new global focus on effective management and elimination/eradication of certain infectious diseases.

## Policy issues

To make use of these new opportunities, we propose that the epidemiological surveillance community:

- Establish collaborative partnerships with climate/environment research and service communities to overcome policy and institutional barriers and identify opportunities for the effective use of climate information in health policy and decision-making. Climate and Health working groups have already been established in some countries which connect ministries of health, national meteorological agencies, and other public health partners around the development of climate services for the health sector. Other innovative partnership structures need to be established that are appropriate to individual settings.

- Build the capacity of health professionals to understand, use, and demand appropriate climate information/environmental information through creation of nested training opportunities in epidemiology and related professional training in schools of public health and other appropriate institutions, including incorporation of climate knowledge and information in field epidemiology training programs.

- Support the research and development of appropriate evidence-based climate products and services for use in health policy and decision-making within the context of the Global Framework for Climate Services "to strengthen production, availability, delivery, and application of science-based climate prediction and services."

- Support national and global investments in routine observation of climate, environmental and health phenomena pertinent to decision-making for climate-sensitive diseases including the Global Climate Observing System (GCOS) and the Health Societal Benefits Area of Group on Observations (GEO) within the Global Environmental Observation System of Systems (GEOSS) framework, with a focus on data access, data management, and data transformation into information and services.

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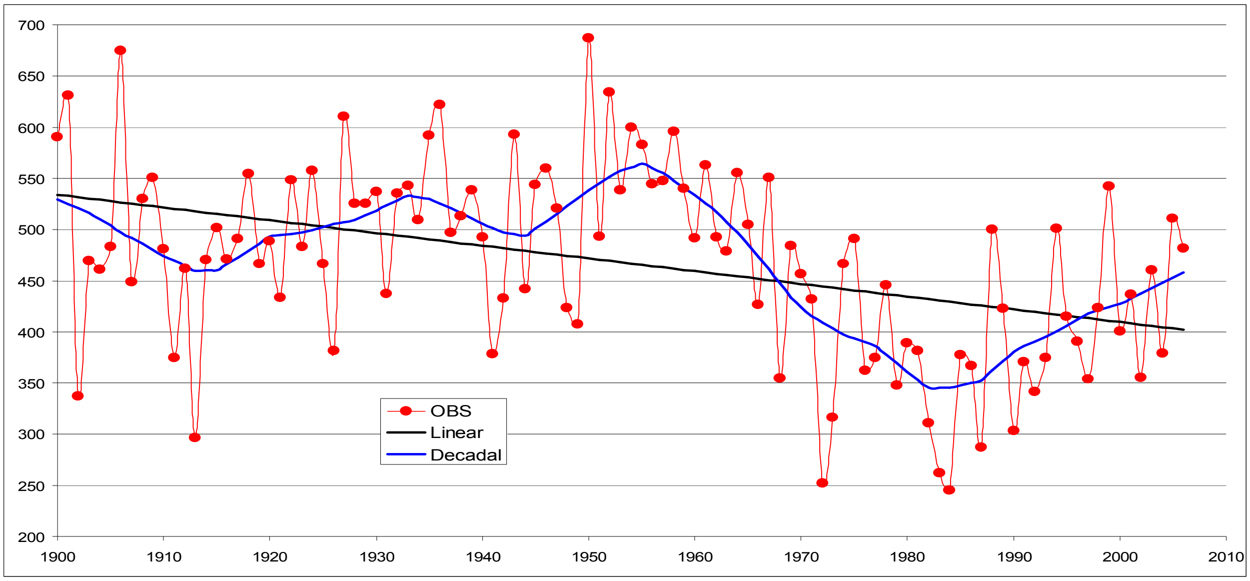
Figure 1:
Variability v. long term changes in rainfall in the Sahel: a challenge to decision-makers.




This one graph indicates the challenge of thinking about managing climate sensitive health risks at multiple time scales. The black line represents the long-term trend in rainfall across the Sahel from 1900 to 2009. A significant downward trend is observed. This is the type of long-term trend that might be predictable in climate change models.

The spiked line represents the year-to-year variability in the same region of the Sahel. Clearly some years are much wetter or drier than others. This is the type of short-term variability that might be partially predicted through operational seasonal climate forecasts based on climate models and El Niño related phenomena.

The curved line represents slowly evolving shifts in rainfall across the Sahel over decadal (10-year) time scales. These shifts are considered as part of the natural cycle of climate variability and are particularly pronounced in the Sahel. Thus the 1970s and 1980s were particularly dry and contain the extreme drought years of 1973 and 1984. This is the type of slowly- evolving variability that is currently the focus of intense research. If it were predictable then many opportunities for better climate risk management would emerge.

Health policy and decision makers need to consider the nature of the climate challenge associated with specific health risks and the information available to respond to that challenge. For the control of infectious diseases the decision opportunities are likely to fall entirely within the year-to-year or decadal time frame.

*** A policy position paper prepared for presentation at the conference on Emerging and Persistent Infectious Diseases (EPID): Focus on Surveillance convened by the Institute on Science for Global Policy (ISGP) Oct. 17-20, 2010, at Airlie Conference Center, Warrenton, Va.*

## Debate summary

**The following summary is based on notes recorded by the ISGP staff during the not-for-attribution debate of the policy position paper prepared by Drs. Madeleine Thomson and Gilma Mantilla (see above). Dr. Thomson initiated the debate with a 5-minute statement of her views and then actively engaged the conference participants, including other authors, throughout the remainder of the 90-minute period. This Debate Summary represents the ISGP's best effort to accurately capture the comments offered and questions posed by all participants, as well as those responses made by Dr. Thomson. Given the not-for-attribution format of the debate, the views comprising this summary do not necessarily represent the views of Drs. Thomson and Mantilla, as evidenced by their policy position paper. Rather, it is, and should be read as, an overview of the areas of agreement and disagreement that emerged from all those participating in the critical debate.**

### Debate conclusions

- While the relative importance of weather and climate as factors in the development and spread of infectious diseases is still debated, changing climatic conditions must be given consideration as potential drivers of disease. This information should accordingly be included in modeling, predicting, and operational decision-making for the control of infectious diseases.

- A cadre of public health professionals who are equipped with the skills and knowledge to integrate weather/climate into infectious disease surveillance is needed. Education and training on weather/climate should accordingly be integrated into public health studies.

- Improvements in evidence-based research and development of climate products/services are needed to make weather and climate information useful for decisions concerning health and infectious disease control.

- Collaborative partnerships and communication are needed among epidemiology, public health, climate, environment, and policy communities to appropriately integrate weather/climate and infectious disease surveillance data. In particular, the climate community must learn to demonstrate the value of weather and climate data for the surveillance and control of infectious diseases.

### Current realities

Historically, the relative importance of weather/climate in the development and spread of infectious diseases has been vigorously debated. While the relevance of weather and climate to infectious diseases in humans was acknowledged, diverse views were expressed concerning the degree to which both factors should be considered in the analysis of surveillance data, especially relative to other variables. Establishing clearer definitions of environmental factors for the public in general and policy makers specifically was deemed to be an important early step in conveying the value of these factors in modeling, particularly when distinguishing between "weather" and "climate." Weather and climate are different, but related, phenomena. It was generally recognized that the term "weather" refers to point-sourced data measuring hourly/daily changes in parameters such as temperature and humidity/rain within specified locations, and that "climate" refers to average weather conditions at a particular place over a long period of time. The differences between weather and climate must be effectively communicated to both the public health community and policy makers.

Most public health experts have not acquired the skills required to accurately integrate weather and climate data into their research or policy recommendations, but more routinely rely on anecdotal information for decision-making. This is because course material focused on weather and/or climate is rarely emphasized in degree programs or professional training in public health. This knowledge base will be necessary for the weather/climate fields to adequately inform health issues, including infectious disease control.

The quantity and accuracy of weather/climate data have both increased dramatically during the past two decades. Tremendous investments have been made to develop and deploy methods and technologies for modeling increasingly detailed and precise meteorological data that are used to improve the accuracy and visual presentation of television weather reports and two-to-five-day forecasts. Additionally, computer-processed data are now available to predict conditions that affect air travel (e.g., wind), forecast snowstorm locations and timing, project typhoons in the Indian Ocean and South China Sea, track hurricanes in the Gulf of Mexico through mapping initiatives, and estimate climate changes worldwide months or years into the future. Such computer-processed data have been termed "climate services products." As a result, the scientific community has a rapidly expanding bank of systematically recorded, temporal weather/climate data that can be incorporated into other studies, including those focused on health issues.

Weather/climate data and public health information, such as that relevant to infectious disease surveillance, are collected and stored in a wide range of formats. These technical issues make it difficult to blend the information obtained from these two fields for the purposes of prediction. Although it is possible to convert these data types into compatible formats, this work can be time-consuming and difficult for those who are not directly familiar with one field or the other. These technical difficulties have become significant barriers to incorporating weather/climate results into the analysis of disease surveillance data.

In wealthy countries, disease transmission is not nearly as dependent on weather/climate as it is in less-wealthy countries. This difference is due, in part, to the issues associated with the quality of building construction, the energy committed to intensive climate controls (e.g., air conditioning), and the resources available from highly industrialized economies. All of these variables reflect the degree of development in a given country.

Thus, while climate data may not be particularly useful in areas such as Europe, the same type of data may play a greater role in poorer, tropical countries where climate-related impacts are especially pronounced on an individual scale (e.g., where substandard housing and inadequate basic infrastructure provide insufficient protection from weather) and on an economic scale (e.g., where livelihoods are heavily dependent on rain-fed agriculture and seasonal water resources). However, the devastation caused by Hurricane Katrina demonstrated that poor communities in wealthy countries are also exceptionally vulnerable to the negative effects of weather events.

It has been recognized that weather variations are among several factors that influence infectious disease transmission and spread. For example, migratory birds carry viral organisms to new locations (e.g., West Nile virus), rainy seasons and standing water enlarge mosquito populations that infect humans (e.g., malaria, Rift Valley fever, dengue fever, yellow fever), and weather-related disasters such as droughts or floods may lead to the appearance and rapid spread of infectious diseases by ruining infrastructure and instigating mass migration (e.g., cholera and measles). Weather variations and extreme weather events, however, do not necessarily cause increases in disease incidence. For example, rainfall surges frequently cause malaria transmission spikes, yet because certain populations maintain a natural immunity to the disease, the incidence of disease does not always increase in proportion to the rate of transmission.

Since weather predictability is only accurate for short time scales (generally 5 to 10 days), its use in predictive models of longer-term phenomena is complicated at best. However, climate predictability does function reasonably well on seasonal scales because it is aligned with sea surface temperatures (e.g., El Niño and La Niña) and therefore, is more useful in predictive modeling including that used for disease surveillance.

Climate can dramatically influence the human food supply, not only through agriculture, but also through aquatic chains. Marine toxins are naturally occurring chemicals that can affect certain seafood. Infectious diseases, such as paralytic shellfish poisoning associated with certain types of seasonal algae blooms in coastal waters, are transmitted to humans when they eat contaminated seafood. These events can cause serious morbidity and mortality in humans.

**Scientific opportunities and challenges**

It was argued that while weather/climate changes are predictors of infectious disease incidence, they play a less significant role than other factors. For example, the worldwide movement of people (e.g., via air travel), as well as socioeconomic factors, was cited as potentially more significant drivers of infectious disease transmission. Understanding the relative importance of weather/climate, versus other variables, as drivers of disease remains the central issue to be resolved if a significant integration between weather/climate data and disease surveillance is to be made.

The existing scientific literature on climate and health is underdeveloped, primarily because the two communities generally work in parallel and do not sufficiently understand each other's needs and functionality. Effective collaboration between climate and health groups remains an ongoing challenge, but opportunities for cooperation exist that need to be promoted.

The tremendous growth in meteorological data over the last 20 years has produced a large amount of information that can be used in tandem with infectious disease data. One advantage associated with creating this knowledge base is its potential for identifying new applications of meteorological information in disease studies. It also provides opportunities to identify practical applications for time-series and cross-geography research that would not necessarily be identified if these data were not available.

While the scientific community is generally adept at incorporating weather and climate information into its studies, the public health community is not widely experienced in this arena. While the public health community is beginning to incorporate weather/climate data into studies and decision-making processes, training this group to use weather/climate data effectively and appropriately remains a challenge due to a deficiency in opportunities for this form of targeted education.

It was evident that more discussion among the climate community, public health, and policy communities concerning how weather/climate surveillance data can be used to inform infectious disease control would be productive for all those engaged in identifying and controlling infectious disease outbreaks.

**Policy Issues**

Despite conflicting viewpoints on the relative importance of weather/climate in the development and spread of infectious diseases, it was asserted that changing climatic conditions should nevertheless be considered in modeling, predicting, and operational decision-making for improving control of these diseases. Although it still is unclear whether other variables, such as socioeconomic status, are more important drivers, it was contended that each factor is an important component of the greater picture characterizing domestic and global changes in infectious diseases and that there is value in quantitatively determining more accurately the relative importance of various infectious disease drivers, including weather/climate.

Although some believed weather/climate factors do influence infectious diseases, it was not clear how weather/climate change information could influence operational prevention and control programs. Accordingly, it was suggested that funding that is currently used to prepare communities to adapt to climate change could be redirected into public health programs, including those programs that focus on infectious disease surveillance. This viewpoint was debated extensively, but without reaching a consensus as to whether funding should be redirected in this manner.

Weather and climate data are routinely and consistently collected, as well as widely available. Consequently, the cost of utilizing that data in health-related studies is relatively small compared with many other data sources. However, attention must be paid to ensuring that this information is appropriately used. Currently, when public health professionals do incorporate climate data into their research it is frequently done incorrectly. A cadre of public health professionals who are equipped with the skills and knowledge to integrate weather/climate into infectious disease studies is accordingly needed. Education and training on weather/climate should be integrated into public health studies, both via degree programs and continuing education modules.

It was noted that changing weather/climate patterns associated with climate change, and our present inability to halt these developments, have been used by some policy makers as an excuse for why infectious disease control and health interventions are not working. It was unanimously agreed that this rationalization is detrimental to positive change. Although most were unsure of how to stop these justifications, several suggested that better research to concretely support or refute these claims would be a step in the right direction.

It was widely expressed that the climate community needs to be able to demonstrate the value of climate surveillance information for infectious disease control to policy makers. Charts and diagrams may not be effective means to communicate the worth of weather/climate information to those in decision-making positions; rather, the climate community must demonstrate a return on investment and target areas where merging climate and infectious disease information has been a proven means of control. The climate community would be well served by demonstrating to policy makers how weather/climate data can be used to more effectively determine where resources should be targeted for the mitigation of infectious diseases.

Better integration of weather/climate data into infectious disease studies can lead to targeted interventions. For example, if it is found that an area is too dry, dams may be built or irrigation programs initiated. It is currently difficult, however, to obtain the political support needed to undertake these types of interventions. Education of policy makers on the importance of valid weather/climate outcomes is, therefore, important. Equally important is the ability of the climate and public health communities to effectively communicate these results to those in decision-making roles.

# Whither Surveillance?**

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## Summary

The global population is expanding rapidly, bringing with it uncertainties of food availability that will be confounded by climate change. These food issues will also trigger political and global tensions. Food animals are now being raised in vast numbers, engendering increased threats of emerging infectious diseases and possibly a catastrophic influenza pandemic at any time. The H5N1 influenza events of 1997 in Hong Kong and of 2003 in eastern Asia, SARS in southern China in 2003, and pandemic (p)2009 H1N1 viruses show the current value and potential future value of surveillance. Yet, there is insufficient appreciation of zoonotic diseases, difficulty of communication, and complexity of commercial and cultural pressures. Surveillance, observation, and awareness become the cornerstones of "influenza intelligence." Now is the time for the United Nations (U.N.) and its agencies to grasp the nettle to provide stronger leadership in dealing with emerging and re-emerging infectious diseases and to promote education about them for the global society it serves. The U.N. must provide the impetus for global understanding and responsibility — not only for control but also for prevention.

## Current realities

In 1968, the United States Surgeon General suggested, "It is time to close the book on infectious diseases [and to] declare the war against pestilence won." However, history proved otherwise. For the next 40 years the world saw the emergence, re-emergence, or re-distribution of a number of viruses, prions (sub-viral), or bacterial infections, leading to a period of unexpected infectious disease problems for humanity. The re-emergence of infectious diseases is multifaceted. Anthropogenic diseases emerged, such as bovine spongiform encephalopathy (mad cow disease), influenza H5N1/97, and Nipah. New social diseases that were exacerbated by socioeconomic and political conditions — the most prominent of which is HIV/AIDS — were recognized. Tuberculosis and childhood infections increased as a result of insufficient basic investment in public health arising from political events. Climate changes drove new geographic boundaries for West Nile and dengue. The first decade of the 21st century also delivered four infectious disease jolts of H5N1 (2003), H7N7 (2003), SARS (2003), and p2009 H1N1 (2009).

The current Director-General of the WHO considers global food crises, climate change, and pandemic influenza to be the three major threats facing humanity. These threats are both mutually exclusive and mutually inclusive. There is a pressing need to raise more conventional food animals [e.g. chicken (H5N1) and pig (p2009 H1N1)] and unconventional animals [e.g. civet cat (SARS) and Bar-headed Goose (H5N1)] in stressful conditions, and there is now greater human encroachment on the animal environment and probably greater use of bushmeat. These conditions may prove ominous for the future.

## Scientific challenges and opportunities

The question arises whether infectious disease outbreaks over the last 40 years have been lessened by better surveillance, better interventions, and/or better actions? On one hand, spread of HIV/AIDS (an infection of misery and a potential long-term human pathogen) was the product of international, national, and local inaction, and an indifference to the emergence and spread of disease from specific parts of the world (Africa), and among certain segments of society. The end product was a global disaster. On the other hand, recognition of H5N1/97, Nipah, and SARS was underpinned by understanding local conditions and awareness — itself derived from a pool of understanding from years of influenza virus surveillance of animals in Hong Kong — and each were dealt with immediately at source by the slaughter of chickens, pigs, and civet cats, respectively. (The Hong Kong influenza model was developed in the late 1970s from continuous virus surveillance. It promoted awareness, particularly among government veterinary and medical officials, to be vigilant of a potential pandemic's emergence. Education and networking among government, universities, and the public bolstered watchfulness and action.). The genesis of the H5N1/2003 virus was charted over four years. Failure to acknowledge its existence led to the "simultaneous" recognition of the virus in eastern Asia for which migratory birds were initially blamed. This represents a failure in responsibility.

Historically, H1N1 pandemics "traceable" to around the 1830s appear to have originated in southern China, although some suggest that the H1N1 pandemic of 1918 initiated in the U.S. The origin of the recent p2009 H1N1 pandemic in Mexico and the U.S. is a departure from the southern China epicenter hypothesis, and is probably the result of the industrialization of pig production. In spite of warning signs from unexpected viral genetic reassortment events taking place in pigs in the U.S., serious surveillance may not have been carried out because: (1) the U.S. is outside the southern China epicenter; (2) it seemed unlikely that, in a world "saturated" with antibodies to H1 and H3 viruses, the genesis of another H1N1 virus could occur; (3) attention was fixated for some time on H5N1 as the next possible pandemic virus; H1, H2, and H3 are the only viruses involved in pandemics since the 1830s, suggesting that there may be a limited range of H subtypes capable of causing human pandemics; (4) of commercial pressures, and (5) of insufficient interaction between industry and government authorities.

Would systematic, proactive surveillance of pigs in the U.S. and Mexico have detected the p2009 H1N1 virus in sufficient time to warn of a possible pandemic? Genetic analysis indicates that initial transmission to humans probably occurred in late December 2008/early January 2009, approximately three months before it was detected in March/early April 2009 (Smith et al, 2009). However, the reassortment events that led to the genesis of the p2009 H1N1 virus in pigs may have taken place three to four years earlier (Smith, personal communication). Accordingly, the answer to the previous question is probably "yes," proactive surveillance would have detected p2009 H1N1 with time for sounding the alarm. However, without a strong link between investigators, industry, and government (as in Hong Kong), we are doomed to be describing diseases post-hoc rather than predictively through proactive surveillance.

**Policy issues**

- The U.N. should be the prime body to lead and to establish a unified global approach to virus surveillance across humans and animals, including wild birds. (A signal of intent could be initiated through the World Health Assembly.)

- Education

  — The science of influenza is complex and needs to be understood by all levels of policy makers from the laboratory to villagers, industry, government, and the U.N. Education is the key to improving human health outcomes.
  — The current generation of government and international policymakers' understanding of EPIDs must be upgraded. This could be mounted in simple interactive courses, using influenza as a model. Organization of these activities could be mounted through institutes like the ISGP, including support from universities and other agencies.

— We cannot assume surveillance systems can run themselves without staff education. This may be achieved by developing courses for prospective administrative staff or undergraduate courses with a stronger science component as parts of degrees or post-graduate courses (e.g. hospital administration courses); restructuring veterinary/university curricula to include greater infectious diseases components and developing new inter-disciplinary courses; and training for extension officers (Shortridge and Gibbins, 2009).

— We must promote the responsibilities of all nations to deal with the influenza problem. Pig/poultry producers and governments should have better interaction and trust to facilitate proactive surveillance. Smallpox and poliomyelitis eradication efforts have set precedence for the effectiveness of international cooperation (Shortridge, 2010).

- Developing global surveillance strategies, particularly at sites with high animal/human interface, is essential to preventing or blunting pandemics.

- It is imperative for humans to move away from animals as a food source. Scientific progress now offers the possibility to genetically harness the power of microbes for large-scale protein production. Benefits include: (1) reduced dependency on production of massive numbers of stressed food animals and the effect on the environment and (2) reduced threats of influenza and other infectious diseases.

- We must ask ourselves, with all the science and technology now available, why is so much effort given to the control of emerging infectious diseases rather than to prevention? (See: early Chinese medical conviction; Shortridge, 2010). In the case of influenza, a mindset change in needed; we must set a goal of no more pandemics. Science needs a focus, a purpose for its application, and a society sufficiently educated to bring it about. Strong, purposeful global leadership through U.N. agencies is immediately required, especially in the face of global food crises and climate changes.

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*** A policy position paper prepared for presentation at the conference on Emerging and Persistent Infectious Diseases (EPID): Focus on Surveillance convened by the Institute on Science for Global Policy (ISGP) Oct. 17-20, 2010, at Airlie Conference Center, Warrenton, Va.*

## Debate summary

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### Debate conclusions

- There are scientific models worldwide where infectious disease surveillance has been judged to be successful. It was generally agreed that the more successful elements of these surveillance programs need to be widely emulated.

- Although the scientific credibility and inherent value of surveillance programs are generally recognized, the resultant information has not generally been used by governmental or societal leaders to shape effective policies addressing infectious diseases in a timely fashion.

- The institutions mandated with the responsibility for world health must do significantly more to improve their role in shaping surveillance programs, interpreting the programs' results, and utilizing conclusions to influence infectious disease policy.

- The design of future surveillance systems must consider how to monitor, quantify, and predict the influence of diverse factors such as animal waste management, vector control, explosive population growth, and local and global climate change. Biosecurity has also become an increasingly important element in the design of surveillance systems.

- To date, the eradication of most infectious diseases has been beyond our current capabilities. More effective use of disease surveillance as a tool to control those diseases is of critical importance if eradication is to become a reality.

### Current realities

There was substantial discussion concerning whether the current ability of the organizations having mandates for global health, such as the United Nations (U.N.) and the World Health Organization (WHO), are failing to meet current needs for disease surveillance given the scope and complexity of global infectious disease threats. A critical aspect of this discussion centered on issues surrounding the urgent necessity to build surveillance capacity and analysis capabilities in countries where the greatest disease risks occur rather than depending solely on external responses. New models for effective disease surveillance based on increased in-country involvement in combination with regional networks are needed to support the international surveillance efforts coordinated by the U.N. and the WHO. The emergence of regional surveillance networks that cross old (e.g., Cold War) geographic boundaries was highlighted as one example of current local capacity building.

The present influenza surveillance system is the most widespread in the world since virus strains can easily and quickly spread worldwide.  Yet, even armed with substantial knowledge of the influenza virus, and despite the high burden of this disease in all countries, the availability of the influenza vaccine has not been greatly expanded worldwide.  During the 2009 (H1N1) pandemic, governmental vaccine distribution systems did not move unused influenza vaccine from wealthy countries to those tropical areas that lack vaccine protection.  This failure to protect overall human health occurred despite strong statements from both the scientific and policy communities declaring that such redistribution was the preferred course of action.

Recent history has provided a highly visible example of an infectious disease epidemic that now is present worldwide, namely HIV/AIDS.  Surveillance provided reports suggesting the existence of the virus and disease for many years prior to their formal recognition.  This delay in acknowledging the emergence of a major infectious disease and the gap between scientific understanding and policy decisions underscores the need to mobilize the political will required to deploy resources in support of those activities that protect populations at risk.  Combating a disease outbreak begins with disease surveillance.  However, surveillance has proven ineffective without the means to mobilize political commitments and convince the public to take those steps that can provide some measure of protection.  The impact of surveillance in controlling an infectious disease can only be substantial if a society provides the resources needed to implement specific actions.  These specific actions must be justified by the appropriate analysis of the evidence uncovered by surveillance.

The Australian livestock industry has developed a five-tier system for indemnification of losses due to disease and their impact on farming conditions.  Similarly, in East Africa, index insurance products have been developed for rural communities to increase incentives for disease reporting and protect livelihoods.  These examples demonstrate the private insurance market's ability to provide more sensitive risk assessment than is typically generated by governments.  The effectiveness of the private sector reflects its ability to understand the financial risks of exposure to diseases and its proximity to the market impact.

As the middle class expands globally, the demand for increased production of food protein from animal sources is intensifying the conditions in which new and persistent infectious diseases in animals may thrive.  Such increased food production opens up new avenues for disease transmission from animals to humans (zoonosis) and increases the likelihood of infectious disease outbreaks that affect both animals and humans.  The challenges of animal disease surveillance include biosecurity, management of animal waste, disease control in highly populated areas, and the effects of local and global climate change — all of which are extremely difficult to monitor, predict, and quantify.

**Scientific opportunities and challenges**

The control of influenza has never been attempted on a global scale.  Only one area in the world, Hong Kong, has a concerted, active surveillance system for assessing the circulation of influenza strains in all animals.  Without establishing a broad network of surveillance systems comparable to Hong Kong's across the globe, widespread control of influenza will not be feasible.  Nonetheless, scientifically credible surveillance methods exist that could be used as models for such a global system.

An active global surveillance system that describes the ecology of influenza is a necessary primary step to management of the disease.  A baseline can then be produced that can be used in models to illustrate changes in the hosts, reservoirs, and circulating strains. To be effective, this system must include data on animals (wild and domestic), the local environment, humans (their health and behavior), seasons, weather, and climate.

The burden of infectious diseases is interrelated across pathogens. For example, immunity against influenza can provide protection against pneumonia. The basic global map now available for the disease burden is not sufficiently detailed to meet current needs and is outdated with respect to the demands of policy makers. New surveillance technologies, including crowd-sourcing and other proxy measures derived from the Internet, are needed to provide a more complete and interdependent picture of the disease burden for a given locale. Clinical and laboratory diagnoses remain of paramount importance.

In the case of food production, the increased use of industrial food methods and practices might lessen small-scale, unreported contamination that occurs at local levels. However, expanded adoption of industrial food production practices might also concentrate contaminants and develop new breeding grounds for antimicrobial resistance. Accordingly, a challenge arises in using the science and technology of surveillance to disentangle whether food-related outbreaks are artifacts of changes in food practices, products of opportunity, and/or new methods of counting.

**Policy Issues**

Public health advances historically resulted primarily from the adoption and provision of good hygiene, water, nutrition, and improved living standards. It was widely questioned whether less-wealthy countries can control influenza when they have other, more pressing, basic health needs associated with good hygiene, water, nutrition, and the quality of living conditions.

There was general consensus that eradication of the influenza virus is not possible since there currently is no way to eliminate the disease from either animals or humans. However, global control of the disease has never been seriously considered. The complexity of the disease, combined with the lack of basic understanding of some science (e.g., how the influenza virus jumps the species barrier) and the basis for accurately assessing immunity, has deterred attempts to propose a widespread control program. There was considerable disagreement concerning whether global influenza control is feasible. It was contended that worldwide control would be possible with the proper programs, resources, and surveillance in place, especially with direct, continuous monitoring of animal diseases. By contrast, it was argued that disease control on a global scale may not be realistic because such targeted programs would require 10 to 15 years to initiate — an impractical goal, especially when the incentives and advantages are distributed across such a wide number of countries, populations, and industries.

Within this context, it is clear that a better, more comprehensive understanding of the origin of pandemics and of the animal-human interface would encourage a generational shift toward disease prevention rather than the primarily disease control approach now used. The experience in Hong Kong with H5N1 supports the feasibility of such a preventive approach.

While many reports urge the implementation of more infectious disease surveillance, it is not clear at what point these efforts produce “data overload,” in which the availability of so much surveillance data makes it more difficult to conduct a proper analysis. Innovative thinking is needed to understand both how disease surveillance can be further improved and how the analysis of that data can be organized and conducted in ways that facilitate their use in policy decisions. It was further contended that to obtain the political and public support required to implement increased disease surveillance, public health communities must better define and communicate the return on investment (ROI) that governments and their respective communities can reasonably expect.

Large (re)insurers have developed many new lines of products to address novel risks. For example, in 2007, personal pandemic influenza policies became available in China. Insurance industry assessments rank infectious diseases as among the highest risks to the global economy. It was agreed that it would be useful to look toward insurance analyses to assess the ROI in surveillance response systems for infectious diseases.

The global burden of influenza is significant. Although an influenza pandemic represents one of the largest catastrophic threats to global economic security, serious vaccination attempts are made only in wealthy nations. Practical and societal barriers to widespread vaccination must be better understood and appropriately addressed to widen the vaccination net and increase protection.

The time required for influenza vaccine production cycles has been massively reduced through technological advances. Companies can now develop seed strains in days with minimal staff. During the 2009 pandemic, vaccine manufacturers demonstrated this capacity by developing strains despite financial risks to the private sector. However, it was noted that the speed of vaccine production, as well as the rate at which the influenza virus is transmitted, routinely outpaces the time required for the regulatory processes to approve action. It was suggested that attention be given to identifying what specific regulatory reforms are needed to align safety concerns with rapid production and distribution of influenza vaccines.

The role of education and training in influenza control was discussed. Greater clarity was sought on the role that distance education (i.e., for individuals in less-wealthy nations) can play in expanding the number of trained personnel in local settings. It was perceived that investing resources in the training of healthcare professionals within less-wealthy countries would be a major step forward in improving disease surveillance.

In many areas where new infections are found and/or predicted, agricultural and health officials are often politically at odds. The strength of agriculture ministries and their promotion of certain practices (e.g., the use of hormones and vaccines in poultry) could increase threats to local and global health. Better communication and cooperation is needed between these two groups to bridge their competing interests.

Increased use of industrial food production practices might reduce small-scale, unreported contamination at local levels. However, it was asserted that new ways of monitoring the often rapid changes in the scope of food-related outbreaks are needed. It was suggested that care must be taken to ensure that recorded changes are due to actual events and not because of alterations in methodologies used to monitor and analyze food-related outbreaks (e.g., ways of counting).

Influenza constantly circulates in pigs, chickens, ducks, humans, and wildlife. However, not all strains have the potential to result in human pandemics, nor are they all lethal to the economic livelihoods of millions of farmers. Although veterinarians are most likely to notice the emergence of a new variant in the animal population, they often have few resources available for monitoring. Accordingly, attention must be given to enhancing global veterinary monitoring for potential pandemic influenza strains.

# Role of Attribution in Global Food Surveillance**

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## Summary

The safety of the food supply has emerged as an important and complex global public health, social, and political issue. Although accurate statistics on the scope of foodborne illness are lacking, the World Health Organization (WHO) estimates that millions of individuals die each year from diarrheal diseases, many from contaminated food and water. Moreover, the economic cost of foodborne illness in the U.S. alone could be as much as $152 billion (U.S.) per year.

Surveillance is vital to providing accurate information on the impact of foodborne illness. Accurate and timely surveillance is needed to limit the scope of outbreaks, identify recognized and emerging sources of foodborne pathogens, and provide critical data for robust risk assessments. In addition, accurate surveillance statistics form the basis for developing and implementing mitigation strategies and directing appropriate national and international food safety policies. However, the current surveillance system in those countries that have them possesses only limited capability and capacity to provide the type and amount of data that stakeholders would need to implement a public health-targeted food safety policy.

Currently available surveillance statistics are valuable in terms of identifying and quantifying causality and developing public health goals for implicated microorganisms but lack the specificity required to make meaningful decisions needed to improve food safety. To do so, surveillance must be able to identify the food in which the organism was present and the geographical region from which the food or food ingredient originated. The term attribution is typically used by public health experts to describe the ability of a surveillance system to link cases of foodborne illness to a specific food or ingredient.

An ideal surveillance system would have to be national or international in scope, but would also require participation at the local and state/provincial level. Although attribution requires considerably more human resources than does conventional surveillance, advances in trace-back technologies, molecular typing and epidemiology, mathematical modeling of epidemic patterns, and advance computing and database management could be employed in the future to minimize the need for personnel while speeding up data collection and analysis.

## Current realities

Accurate attribution of foodborne illness to specific food vehicles is an important goal for both the private sector and the public health community. However, that goal has been largely unattainable given the scope and complexity of the problem and the limited effort being given to achieving the goal. The current realities illustrate the scope and reasons why attribution has not occurred as desired.

The most recent estimates published by the U.S. Centers for Disease Control and Prevention (CDC) estimate that as many as 76 million cases, 325,000 hospitalizations, and 5,000 deaths are caused by foodborne illness each year in the U.S.

Current surveillance systems are primarily focused on the organism rather than the vehicle (food). Without knowing the vehicle, developing strategies to improve safety is hampered.

In many countries, there is significant underreporting of foodborne illness. Consequently, emerging pathogens and foods of potential concern are missed.

Recent outbreaks have involved foods that were previously thought to be low-risk. Likewise, many of the largest outbreaks have been traced to unidentified ingredients in complex, multicomponent (multi-ingredient) foods.

Federal research efforts are focused on fundamental rather than applied solutions. Attribution would provide the basis for additional funding on microbial ecology of foods, mitigation strategies, and detection methodologies for organisms in foods of highest concern.

Food safety has become a major issue in international trade, and foreign-sourced food makes up a growing percentage of food for most countries. Food safety is sometimes used as a trade barrier and excuse for countries to limit imports.

Most regulatory decisions, while saying they are risk-based, are typically NOT based on public health data. Little data exists on which to base risk-based decisions. Hence, current regulatory policy tends to be more "overarching" rather than focused on foods and practices/processes of greatest risk.

**Scientific opportunities and challenges**

Acquiring knowledge of which specific foods are of highest risk for certain pathogens will help identify novel new processing techniques to improve safety.

Identification of high-risk foods, contributing factors, and environmental antecedents can help to focus risk assessments more effectively. Risk assessments are required by the World Trade Organization (WTO) in trade disputes involving food safety issues. As more data is available for such risk assessments, the validity and utility of their results to the scientific community increases.

Advances in communication and sharing of vital food safety data by the food industry and domestic and international public health agencies can enhance early identification of problems. An example of the contribution of such communications networks is the CDC's PulseNet system for comparing genetic fingerprints of foodborne pathogens. The implementation of PulseNet is largely responsible for early identification of most of the multistate foodborne outbreaks in recent years.

Expanded use and the development of new and more refined techniques for molecular epidemiology and typing can help match specific strains of pathogens to ecological niches (foods). In addition, it enables investigators to trace contaminated foods and ingredients back to their sources (a process known as traceback) .

**Policy issues**

Attribution of foodborne illnesses could have major policy implications. Attribution of illness to a specific commodity, region, or brand could change the level of risk category to which that commodity is assigned. This could increase regulatory scrutiny and actions for that commodity, influence policy decisions aimed at that category of food, and affect international trade. In contrast, having the ability to attribute illnesses and outbreaks to more specific circumstances would allow more informed public health decisions, improved public messaging, more focused government research funding, effective preventive controls regulation, and increased confidence in governments and trading partners.

- Current and future regulatory actions are dependent on identifying the most effective corrective or preventive strategies. Better attribution must be employed so that policy makers and regulators can focus on highest-risk foods and pathogens and make more effective public health decisions. Key implementers of attribution strategies include local, national, and international regulatory agencies working closely with surveillance agencies, such as state departments of health, the CDC, and the WHO.

- Food safety issues can impact both international trade as well as public health. Because a large percentage of foods and ingredients is traded in international commerce, adulterated products produced in one part of the world can cause major outbreaks in another part of the world. It is critical that public health officials, regulators, and food companies have a means to attribute contamination to the correct source. The inability to do so is cause for mistrust between trading partners, flawed trade policy, and destabilization of prices.

- Federal budgets have tended to fund fundamental research which focuses on mechanisms of disease but have largely ignored applied research to prevent foodborne illness. A better balance of federal funding must be achieved to improve food safety through the acquisition and use of attribution data.

- Building an effective attribution system will require significant funding. Much of this funding will need to be directed to local/state/provincial partners who actually conduct the surveillance and to developing standardized data collection systems so that data from multiple sources (local, state, provincial) can be rapidly collected and analyzed. Hence, it will be necessary to inform and convince government leaders that such a system will result in measurable improvements to public health.

- Some countries have implemented national mandatory reporting for all foodborne illness. Such mandatory reporting is a critical first step in achieving a global foodborne illness attribution system and should be implemented by all countries which trade in agriculture and food.

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## Debate conclusions

- Given the reliance on the global food supply chain and the increasing international awareness of terrorism, surveillance of foodborne illnesses as well as events involving intentional contamination of the food chain have become a priority. In general, food safety and security has become a national security issue.

- The use of ingredients sourced from numerous international suppliers, together with the just-in-time delivery system itself, emphasizes the need for surveillance systems that can quickly identify the specific vehicle and pathogen/agent involved in a given food safety incident.

- Some surveillance systems, such as PulseNet, have proven to be successful and should continue to be replicated and expanded internationally.

- Surveillance systems having diverse objectives (e.g., monitoring the safety of food versus the health of animal or human populations) need to more accurately recognize and utilize the operation of the common food delivery infrastructure.

- It is increasingly recognized that surveillance focused on preventing natural and intentional harm to the food supply is required to ensure the security and prosperity of a country. The responsibility for such surveillance involves both domestic and international policy decisions.

- Developing greater working partnerships between industry and government is essential to creating an effective food surveillance system.

## Current realities

Repeated food safety incidents, such as the cases of *Salmonella* (in peppers, peanut butter, and eggs) and *Escherichia coli (E. coli)* (in ground beef) have eroded the public's trust in the food industry and food safety regulatory agencies. In the United States alone, a recent Pew Trust report found that such food safety incidents cost more than $152 billion (U.S.) due to medical costs (not including lost productivity). The current food surveillance system is not quick enough and does not allow for attribution that is specific enough to help make timely policy and disease management decisions.

There was agreement that the food surveillance systems in some U.S. states have proved to be effective, some even outstanding, as demonstrated by their repeated success at regularly unraveling foodborne disease outbreaks. Additionally, it was highlighted that some U.S. states have a good framework for disease surveillance while others must more heavily rely on help from the federal government. Foodborne Diseases Active Surveillance Network (FoodNet) and

PulseNet, both managed by the Centers for Disease Control and Prevention (CDC), were cited as successful surveillance initiatives.

FoodNet, a component of CDC's Emerging Infections Program (EIP), is a collaboration involving the CDC, 10 EIP sites across the U.S., the U.S. Department of Agriculture (USDA), and the Food and Drug Administration (FDA). PulseNet is a network of public health and food regulatory agency laboratories across the U.S. The PulseNet laboratories perform standardized molecular sub-typing (or “fingerprinting”) of foodborne disease-causing bacteria by pulsed-field gel electrophoresis (PFGE). These DNA patterns are submitted electronically to a dynamic database at the CDC and are available on demand to participants, thereby allowing for rapid comparison of the patterns and quicker identification of related cases or outbreaks. However, compliance of healthcare professionals with these programs varies for different reasons, including cost and time associated in culturing fecal samples. While there are numerous similarities in procedures and common infrastructures among these surveillance systems, differences exist that reflect the various subjects or survey populations examined as well as different laboratory networks and capacities. These types of disease surveillance systems have been successfully replicated internationally, leading to programs such as PulseNet International. Such efforts should be expanded.

Because of the damage and negative public backlash suffered by the food industry as a whole when a few producers are negligent, the private sector is willing to vigorously assist regulatory agencies in investigating food incidents. Negative food incidents are a detriment to the food industry because they lead to loss of public trust and eventually to decreased market share. The discussion recognized that surveillance systems have not always correctly determined the cause of a food incident, which has led to economically disastrous policy or regulatory decisions. This was exemplified by the wrongful blame placed on the tomato industry during the 2008 *Salmonella* outbreak, which eventually was attributed to peppers instead of tomatoes.

As a whole, the existing food regulatory and surveillance system is fragmented and not very efficient. This is due, in part, to numerous agencies being charged with responsibilities for different food products. However, an absence of political will and outdated laws currently prevent meaningful changes from being undertaken. The budgets and human resources allocated to many of these agencies are not sufficiently large to permit them to meet their mandated responsibilities for disease surveillance in foods. In addition, every year, the FDA audits few of the food production facilities it regulates.

It was widely agreed that a terrorist act carried out through the food system in the U.S. is highly improbable. Yet, it was also noted that a terrorist attack on the food supply could be catastrophic, not only in terms of the morbidity and mortality involved, but also because of the economic damage that would be done. The food industry is especially vulnerable because of its reliance on the “just-in-time” model in which products are constantly on the move and often reach the end user within hours after being manufactured. The food supply chain is highly complex, involving the global import of ingredients to be used in multi-ingredient products requiring rapid transport and distribution. Such an attack on the food supply can also be anticipated to have catastrophic impact on a wide range of corporate activities in general, and therefore have seriously harmful consequences for the country at large.

Vulnerabilities in the current food system have been shown through the intentional adulteration of products that ended up in the consumer channel, such as melamine-tainted pet food and dairy products. An improved surveillance system with better attribution could be used to identify such incidents earlier and would be able to trace offending ingredients to their origins. Economically motivated adulteration of food is an important problem that requires investigation.

Typically, disease surveillance is normally focused on identifying the pathogen or organism in the food associated with a specific incident and does not emphasize the longer-term issues of identifying the vehicle involved. This separation of short- and long-term goals also reflects the efforts of governmental funding agencies in supporting research activities focused on basic research rather than supporting applied research having more specific, short-term goals. The importance of applied research in strengthening disease surveillance systems was considered, especially since new technologies already exist that could be harnessed and applied to food surveillance. These newly available techniques are exemplified by the use of genomics to identify pathogens or agents that have already made important contributions. In general, however, these new techniques emerge from the successes of basic research and therefore it was recognized that supporting a blend of basic and applied research programs remains the correct direction to take.

The food industry does not always know which production chain modes on which to focus with regard to safety issues. Novel or stealth foods have been involved in contamination and foodborne illness. Contamination from these foods has rarely, if ever, been identified. Pathogens present in these foods survive processing and sometimes even Hazard Analysis and Critical Control Point (HACCP) programs.

In some countries, food safety is directly related to food security and politics and often is not reflective of sound scientific understanding. Food defense activities and negative events of intentional tampering are scalable and subject to copycat events, which may mask subsequent acts of tampering. These events are scalable because of the nature of the food supply chain. If an ingredient that is integral in many secondary products is intentionally contaminated, then many more people or countries are potentially affected. This makes the need for an effective food surveillance system with better attribution critical.

**Scientific opportunities and challenges**

It was suggested that the HACCP system is becoming outdated. This view was substantiated based on food incidents related to producers that had a HACCP program in place. It was recommended that HACCP be used only in conjunction with other programs to improve the overall effectiveness of food safety programs.

The expansion of PulseNet was suggested for use with other molecular techniques to supplement pulsed field gel electrophoresis. The use of these molecular techniques allows more specific attribution of pathogens involved in food incidents. It was also suggested that surveillance should occur as far down the food supply chain as possible, targeting the individual ingredients used to produce composite products. This procedure would mirror the surveillance currently used in the pharmaceutical industry.

**Policy issues**

Consensus was reached on the need to continue the expansion and replication of programs such as FoodNet and PulseNet, especially internationally. These programs could be organized at regional levels as a mechanism to develop a more effective global system. It was also strongly recommended that the food surveillance capacity of local communities, regions, and countries be significantly expanded and brought into compliance with globally accepted standards now under discussion. Assessments of current local, countrywide, and national systems need to be conducted and the results made public. Private sector companies would find this information exceptionally useful in their efforts to support business ventures in locations where robust food safety systems are required to ensure the quality of their products.

A change in the process of policy-making in the arena of surveillance, from a top-down to a bottom-up approach, was a common suggestion that was strongly supported. This centered on the idea that many organizations, such as the World Health Organization (WHO), are not currently effective in meeting their mandate to conduct effective food safety surveillance. By recognizing the needs of a given country and/or region through placing critical decisions with local authorities, the system would more effectively ensure food safety. This bottom-up approach would foster the development of capacity at a local level. It was also recognized that improvement in the capacity of existing international agencies, such as the WHO, is a component of a functional food safety system, since that is necessary to ensure the interoperability of surveillance systems created in different regions and/or countries.

It was strongly recommended that food surveillance systems need to be developed in parallel to the development of a complex food supply chain. It was concluded that such coordination can be achieved by strengthening the partnerships among government, industry, and academia to ensure that food surveillance is conducted in a manner that recognizes the demands of a global food supply chain.

There was general consensus that it is necessary for funding agencies to redistribute the focus of their funding from basic research toward more applied research designed to provide the technology and data that would help governments and industry evolve food surveillance systems to meet the rapidly advancing needs and expectations of the public.

The debate identified the importance of characterizing the potential role of food in terms of a terrorist target. Although there have not been significant cases of major terrorist attacks on the food supply, there are several examples where criminal acts involving intentional contamination of products (e.g., baby formula and Tylenol) have proved deadly. Countries view the importance of food as a possible terrorist vehicle differently, and if an attack on the food supply was scaled to regional or national levels, it would represent a catastrophic event affecting not only human health but global economies.

The increased use of risk assessments for making policy decisions on food surveillance and food safety was strongly endorsed. These risk assessments would generate better information for policy makers to use in formulating decisions. Although in general there was agreement that templates for risk assessments and mitigation strategies should be standardized, allowing uniformity among local, regional, and international actors, there was some debate over who would develop and “own” these tools.

The idea of placing taxes on food products to provide funds for surveillance or regulatory functions was discussed, but not widely supported. While it was indicated that the food industry would not support taxation, many believed that the food industry would instead be willing to financially support applied research that directly improves food safety.

There was disagreement on whether the food industry had reduced its focus on quality assurance in favor of using post-production surveillance to identify incidents of contamination before products reach end users. It was agreed that it is ineffectual for industry to choose between these two measures, but rather that the food industry must consolidate prevention, surveillance, and quality assurance into one program to improve the safety of food products.

The suggestion was made to shift the responsibility for food safety from the producers back to the public through education. However, it was felt that in today’s world of consumer advocate groups, this suggestion would not be supported due to the public’s increasing demands for safety guarantees. Despite these demands, consumers themselves generally do not take responsibility for implementing even simple measures (e.g., proper cooking temperatures) that could drastically reduce the number of cases of foodborne illness.

Differing views were expressed concerning the effectiveness of Country of Origin Labeling (COOL) as a tool in strengthening surveillance. In general, it was concluded that such labeling is ineffective. While some viewed it as a useful tool because of the highly complex food supply chain, a final composite product may have ingredients from all over the world and the origin of suppliers may vary substantially as well. It was believed that this dispersion would make effective traceback very difficult for a food incident.

# Surveillance for Livestock Diseases That Impact Food Security and Food Safety**

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**Summary**

Livestock play an important role around the world as a source of food, income, fuel, and fertilizer, and contribute significantly to the food security and nutrition of people in both urban and rural areas. Approximately one billion people in poverty derive their livelihoods from livestock, a sector that in developing countries accounts for more than one-third of the agricultural gross domestic product (GDP). Those in poorer developing countries are more likely to own livestock, live in closer association with their animals, yet also have little in the way of animal disease prevention or control, veterinary care, or disease surveillance. It is from these same developing countries that many new diseases emerge on the global stage.

Having efficient national surveillance and monitoring systems for animal diseases and zoonoses in domestic and wild animals is now widely considered essential to understanding and combating diseases that threaten animal/human health and food security, and is a recommendation of this paper. Such systems should be able to rapidly detect diseases early in their emergence and generate reliable information on disease situations within the countries. Surveillance systems are not a "one size fits all" solution for every country, but should be tailored. More emphasis should be placed on establishing such surveillance and reporting systems in poor countries, where the need is greatest and where diseases are most likely to emerge. Additionally, closer collaboration between animal health, human health, and environmental sectors at the country level are needed to accurately identify and address emerging and persistent disease threats. Challenges in developing a surveillance system range from design and funding issues to community concerns and political backing.

**Current realities**

Livestock diseases disrupt trade, negatively impact local and regional economies, exacerbate poverty, and reduce production and productivity. From livestock come a number of diseases that threaten food safety, food security, and human health. Zoonoses from livestock can cause significant morbidity among humans, leading to chronic disability, long-term loss of income, and medical expenses. The mechanisms to collect, analyze, and disseminate information regarding animal health or food safety problems are often minimal in areas where livestock are most abundant, as are systems for detecting outbreaks and emerging pathogens.

It is believed that 30 percent of people in industrialized countries suffer from foodborne illnesses of animal origin every year, but the cost of foodborne illnesses in many developing countries is not fully known since such cases are often not reported, and systems to track such illnesses are uncommon. In the United States, foodborne illness outbreaks linked to animals are estimated to cost more than $8 billion (U.S.)/year. Globally every year, many zoonotic diseases continue to have a tremendous impact on health, food safety, livelihood, and trade (e.g., anthrax, brucellosis, tuberculosis). Poor infectious disease surveillance and control efforts have led to the global spread of diseases of major zoonotic importance, and from responses to these we have learned that disease surveillance systems must incorporate animals, humans, and ecosystems. Population-dense animal operations, the clustering of these facilities near urban populations, and the movement of animals, people, and pathogens between intensive and traditional production systems all coalesce to amplify risks to animal/human health and food security. Climate change will also contribute to this mix, altering the landscape of disease and insect vector distribution, wildlife habitat, and the timing, frequency, and severity of outbreaks. Surveillance programs will be challenged by all of these. Animal disease surveillance systems exist at the international level and, to some degree, at the regional level. Some countries have national systems, but this is less common in developing countries, where diseases are most likely to emerge. One international system is the Global Early Warning System (GLEWS). GLEWS pools up-to-date information collected by the Food and Agriculture Organization (FAO), the World Organization for Animal Health (OIE), and the World Health Organization (WHO), to better detect emerging diseases (zoonotic and nonzoonotic) earlier and thus contain and control epidemics. These systems only function where information at the local level is available. One major lesson learned in the fight against avian influenza "is the central importance of efficient surveillance, effective intersectoral collaboration, a well-designed national strategy and sustained political will (Anonymous, 2008)."

Economic and animal life losses from the spread of transboundary diseases can be monumental: the 2001 United Kingdom foot and mouth disease (FMD) outbreak led to 6 million dead animals, agricultural economic losses of £3.1 billion (U.K.), and a heavy decline in tourism; bovine spongiform encephalopathy (BSE) caused a $20 billion (U.S.) economic impact; and avian flu had more than $10 billion (U.S.) in impact. Yet, rinderpest — the second disease in history to ever be eradicated — once ravaged Europe, Asia, Africa, and the Middle East. Its toll on livestock, wildlife, and humans ultimately garnered political will, leading to its eventual eradication. Such an accomplishment would not have been possible without active surveillance programs in place.

### Scientific opportunities and challenges

It has been considered "inappropriate to formulate a 'one size fits all' response to disease because people and countries are affected differently depending on their economic circumstances (Anonymous, 2008)." Similarly, there is no one solution to animal disease surveillance. This will vary by country, region, culture, level of endemic disease, funding, and trade level. Surveillance systems, among other things, must be cost-effective, flexible to fit any disease or condition, rapidly implementable, and give a good picture of animal health within the country. But they should also be able to detect and identify unusual events and sound an alarm. The effectiveness of surveillance depends upon support and aid at the local level, cooperation and communication between agencies, and unwavering political support. For this support, the objectives of each animal disease surveillance system must be defined and understood by those involved at all levels. Challenges to building a country-level surveillance system in developing countries are many and certain questions have to be answered:

- What is the laboratory capability to detect a pathogen?
- Where should sampling take place (e.g. slaughter plant, points of sale)?
- How is the information collected and shared, and who is entrusted with it?
- Are there people trained in the appropriate fields (e.g. microbiology, epidemiology)?
- Is there cooperation among country agencies/ministries?
- How are animals identified and products tracked?
- What will be the outcome of the system, and how will outcomes be distributed and used?
- What technology will work in a country, and who will train the workers in it?
- How will the system be paid for?

Developing a system means engaging citizens and educating them on how this system will translate to saving money, protecting animal/human health, and opening trade. Challenges exist in reaching out to the community, incorporating wildlife in disease recognition and reporting efforts, and in understanding the farmer's position. The importance of disease detection and reporting by veterinarians, farmers, animal workers, and community members must be a message that the government stands behind. Risks and incentives vary with the farmer and the type of production method used (e.g. intensive production versus traditional production), and poor countries face different incentives than wealthier ones. Challenges also exist in bridging the gap between sectors and ministries. Risk assessment of animal and food systems is needed. Analysis of animal systems, markets, transportation systems, buying/selling, slaughtering, cultural sentiments/beliefs, and occupational attitudes pose challenges to a successful surveillance system and require scientists, social scientists, political scientists, and country leaders to work together.

**Policy issues**

Incursion of disease in a country can mean the loss of export markets valued in billions of dollars per year. This, in turn, impacts livelihoods, food security, lowers GDP, and can initiate economic/ political instability. Countries have different priorities and varying funds to dedicate to surveillance. Policies advocating international support help not just a given country, but other countries as well.

- In creating and maintaining animal disease surveillance programs, policies must be developed that encourage intersectoral collaboration and the protection of animal/human health simultaneously. Such policies should consider the small livestock holder or gender issues that may occur. Policies also must outline: who maintains the system, who sends alert notices, and how control measure decisions will be carried out; who should keep surveillance data, and who should have access to it; how concerns of commodity groups and farmers about litigation or unwanted attention can be addressed; and how policy can balance confidentiality with the protection of health, food security, and trade.

- Cross-border and regional surveillance are complementary to national surveillance, so agreements with neighboring countries must be encouraged.

- Funding for surveillance should tie in with national animal identification and tracking programs, national laboratory capacity, and indemnity payments to farmers (if necessary).

- Policy makers need to understand the many ways in which livestock support livelihoods and improve food security, and the wide reach livestock have on their general economies.

- Policies should encourage transparency in disease reporting and not punish animal producers by forcing them to shoulder the cost of disease containment.

**References**

Anonymous. (2008). Contributing to One World, One Health: A Strategic Framework for Reducing Risks of Infectious Diseases at the Animal–Human–Ecosystems Interface.

*** A policy position paper prepared for presentation at the conference on Emerging and Persistent Infectious Diseases (EPID): Focus on Surveillance convened by the Institute on Science for Global Policy (ISGP) Oct. 17-20, 2010, at Airlie Conference Center, Warrenton, Va.*

## Debate summary

**The following summary is based on notes recorded by the ISGP staff during the not-for-attribution debate of the policy position paper prepared by Dr. Radford Davis (see above). Dr. Davis initiated the debate with a 5-minute statement of his views and then actively engaged the conference participants, including other authors, throughout the remainder of the 90-minute period. This Debate Summary represents the ISGP's best effort to accurately capture the comments offered and questions posed by all participants, as well as those responses made by Dr. Davis. Given the not-for-attribution format of the debate, the views comprising this summary do not necessarily represent the views of Dr. Davis, as evidenced by his policy position paper. Rather, it is, and should be read as, an overview of the areas of agreement and disagreement that emerged from all those participating in the critical debate.**

### Debate conclusions

- The significant impact of animal diseases on human health, as related to social, economic, and political realities, is a critical issue that must be considered in designing almost any infectious disease surveillance systems.

- Systems for livestock surveillance require design considerations and investments tailored to the needs of specific communities in both less-wealthy and wealthier countries. Synergies and advances could be achieved through integrating livestock, wildlife, and human health surveillance infrastructures.

- Contamination and methods of disease containment and prevention are continuing challenges in the cross-border movement of livestock and food. The use of vaccination in protecting "at risk" livestock from certain diseases that would subsequently permit the animals' inclusion in the human food chain is not yet widely accepted.

- Incentives are needed for timely and accurate disease reporting. Currently, the consequences of identifying livestock diseases are often perceived to be punitive by food producers as well as by local and regional governments. These consequences often have deleterious effects on economies.

- The current variability of standards for surveillance of animal diseases diminishes both their individual and collective value. Setting appropriate standards locally and regionally will be a significant step to improving the effectiveness of animal surveillance.

- The surveillance capability directed toward animal diseases needs to be increased in a manner that makes it sustainable, especially in developing economies where it may not be seen as a policy priority. This goal can be achieved by improving local livestock husbandry and veterinary skills and by delivering support in a culturally sensitive manner.

**Current realities**

The role of animal disease in the overall structure of human disease surveillance involves a complex, overlapping set of priorities. First, livestock diseases have a significant impact on local and regional economies. Disease outbreaks among animals can worsen human poverty and reduce overall productivity both locally and regionally. Second, with a growing world population there is an ever-increasing need for animal-derived protein as a food source. Third, infectious diseases that spread throughout animal and human populations separately can independently cross country borders. Fourth, zoonotic diseases that cross from animals to humans pose significant threats to human health worldwide while simultaneously threatening the protein supply as a food source.

Concern was expressed that if animal protein sources become scarce from infectious disease or from measures required to counter such diseases (e.g., livestock culls, bans on importing/exporting), already fragile political and economic regimes may further destabilize. Livestock surveillance for animal diseases is, therefore, of relevance to national and international security even if these diseases do not spread to humans.

There are many changing patterns of human behavior that relate to the intersection of food and infectious diseases. For example, changes in animal husbandry and farming methods as well as increasing urbanization all influence the risks of infectious diseases, especially in domesticated animals. Additionally, less-wealthy countries often have greater dependence upon their livestock both as a source of economic well-being and as a food source. These same individuals routinely live close to the animals. These factors make it exceptionally complicated, both technically and from a societal perspective, to effectively conduct disease surveillance in livestock.

Recurring climate conditions, climate change, and local weather fluctuations are major factors affecting the appearance of infectious diseases in livestock. A variety of mechanisms must be considered for vector distribution and wildlife habitat changes.

Livestock disease surveillance is inadequately funded either because meager resources in general are available for its support, even in wealthy countries, or there is a low priority for disease monitoring in animals within governmental organizations. The World Bank, for example, has only one person dedicated to livestock issues in Africa. Similarly, the United States Agency for International Development (USAID) has few people devoted to issues associated with livestock diseases, although historically many diseases affecting humans have originated with the animal populations living near humans. An observation was made that funding is often directed at individual, specific diseases, but it is frequently unclear why such choices are made. There often is no apparent rationale or strategy identified.

Funding available for livestock disease surveillance does not meet the significance or scale of the related human health implications and issues were raised regarding how and when funding becomes available for animal surveillance. Funding is often allocated only after a significant event affecting human health has been identified (frequently via a disease outbreak in the human population). The comment “human health will always trump animal health” was made. However, no such funding difficulties were experienced during the Hong Kong avian influenza outbreak, wherein animal disease monitoring was given priority.

Livestock issues are regularly left to private industry to address, and routinely are associated with that industry’s own agenda (e.g., protecting a specific product). Less-wealthy countries are often poorly supported in the arena of disease surveillance in livestock. In addition, animal health professionals often feel undervalued and held in low esteem by their human health counterparts, a phenomenon observed in both less and more wealthy countries.

Wildlife and plants are often omitted from the surveillance equation. Professionals from each specialty routinely work in isolation from one another and there is little crossover between their professional training. Moreover, relevant public health education is sometimes neglected in the training associated with livestock and animal health.

The "One Health" paradigm was a frequent topic of the debate. The value of integrating services for human and animal health (including wildlife) surveillance was underscored as a critical effort to be undertaken if disease surveillance in humans is to be improved. Even though the meaning of "One Health" remained open to interpretation, the concept of integrated disease surveillance to encompass animals and humans was strongly endorsed. Internationally, the United Nation's (U.N.'s) Food and Agriculture Organization (FAO) is increasingly concerned that diseases present in animal wildlife will contaminate domestic animals, thereby creating further challenges for protecting the food chain.

Cross-border contamination and the spread of infectious diseases such as West Nile and foot-and-mouth disease (FMD) into the United States are indicators of why coordination between disease surveillance in animals and humans is important. Both positive and negative consequences emerged. The work at Plum Island is a good example of how training opportunities, focused on certain foreign diseases, can be offered. The West Nile experience in the U.S. illustrates that surveillance can be undermined by the incompatibility of data systems used by various agencies (e.g., USDA and CDC). Similar problems were noted for international organizations. The fact that agencies could not communicate hampered effective collaboration and response.

Concern was expressed that regulations need to be tougher regarding the importation of livestock and livestock products. The Australian system, where strict entry requirements are enforced, may provide good guidance.

There was much discussion concerning the potential negative ramifications on the individuals, livestock communities, and even countries reporting an outbreak of an infectious disease in animals. For example, livelihoods may be ruined for farmers whose animals are infected (e.g., via the slaughter of their animal commodities). Moreover, the wider economy can be greatly harmed not only by the animal disease itself, but also by an ineffective reporting process. This was witnessed during the 2001 United Kingdom FMD outbreak (in this instance, both the agricultural and tourist industries were devastated). The political and economic consequences of infectious disease reporting may undermine the effectiveness of disease surveillance in livestock. Rather than "shooting the messenger," there was wide support for developing systems that incentivize timely and accurate reporting for all stakeholders (e.g., food producers).

Paradoxically, the geographic and demographic areas with the weakest capacity for infectious disease surveillance in animals are those where animal-specific infectious diseases are most likely to emerge. How such capability for surveillance can be developed globally was vigorously debated, but it was difficult to identify any simple model that did not involve providing substantial resources to offset the financial impact of controlling a disease outbreak. Any comprehensive surveillance system that promotes accurate reporting must begin with a consideration of local conditions and sensitivities of the agricultural communities directly affected.

Currently, surveillance and monitoring standards vary greatly across different regions, countries, and communities. As a result, the types of information collected are so irregular and diverse that useful comparisons are rarely found. Even in wealthy countries, accurate information regarding the cost of foodborne illnesses is not routinely accessible. However, using U.S. data, it is estimated that the cost of foodborne illnesses is $152 billion (U.S.) per year. It has also been estimated that approximately 30 percent of people in wealthy countries suffer from foodborne illnesses of animal origin every year. Although it is believed that the reporting of foodborne diseases is underestimated in less-wealthy countries, foodborne diseases are still considered to present serious problems in these countries where the infectious disease surveillance infrastructure is often rudimentary.

**Scientific opportunities and challenges**

Surveillance of emerging infectious diseases is most useful when pathogens are identified at their source. Awareness of this reality supported the development of the "One Health" approach, wherein surveillance is conducted holistically across animal and human spheres. Barriers to this approach include challenges in collecting appropriate metrics, sharing data across disciplines, and developing the tools necessary to make linkages between animal and human health clearer.

Vaccines that are becoming available for animal-based infectious diseases (e.g., for FMD) could potentially curtail outbreaks in both animals and humans. However, vaccinated livestock are not currently accepted into the human food chain as a matter of policy. Acceptance of animal vaccination and the associated technology may depend on the ability of the scientific community to distinguish vaccinated cattle from infected cattle, a research area that needs immediate attention.

The practices used in the collection of surveillance data identifying the presence of the disease, as well as characterizing its properties, have improved for some specific diseases, but in general require improvement. Significant advances in disease data collection could be made if the successful methodologies currently directed at a specific disease, species, or population were creatively applied to other diseases and population groups. In addition, disease surveillance may be more effective and efficient if approached holistically whenever possible. For example, dual testing (i.e., in which multiple conditions are tested simultaneously) could be applied more widely. Organizing disease surveillance systems that cross disciplines is essential, but the major challenges remain primarily issues of policy within organizations and between countries. Rigorous laboratory discipline will be critical in building the necessary trust for this type of cross-discipline, cross-border approach.

Since animal diseases often reduce livestock populations, it would be useful to obtain an accurate understanding of how reductions in the availability of protein in the food supply impact human health. It also would be useful to obtain similar types of information concerning the influence on human health from decreases in poultry and egg production caused by influenza outbreaks. These types of causal relationships, if significant, are relevant to the policy community's agenda when assessing the value of disease surveillance in animals.

There is fragmentation in almost all surveillance systems well beyond the separation of disease surveillance for animals and humans. For example, comprehensive disease surveillance systems need to integrate data on animal and human health, climatic conditions, population and societal variations, and ecological influences.

**Policy issues**

It was uniformly agreed that widespread adoption of a "One Health" paradigm is needed for infectious diseases, particularly those that relate to food. It was clear that major steps are needed to learn how to integrate a "One Health" approach into existing disease surveillance models, into the creation of joint animal/health training initiatives, and into greatly diverse types of disease surveillance infrastructure now found globally. In addition, it was suggested that disease surveillance should not only integrate animal and human health but also take into consideration climatic, ecological, and societal factors. Given the potential impact of animal-based infectious diseases on human health, international economic prosperity, and border security, it was concluded that substantially larger investments in livestock surveillance are needed.

There were several specific issues endorsed as steps in the right direction. Future surveillance systems must recognize and incentivize the critical need for timely and accurate reporting from farming and food-producing communities. A multinational perspective is needed to create a high quality "One Health" approach. Creating internationally accepted standards for disease surveillance would ensure uniformity and, thereby, comparability of the surveillance information collected. In this latter case, it was suggested that standardization be viewed as a two-step process, in which the principles and objectives of animal surveillance are agreed upon, and performance standards then established. Modest efforts are already under way in this arena, particularly within the World Organisation for Animal Health (OIE), which provides standard guidelines as a tool for assessing the veterinary infrastructure of countries.

It was noted that policy makers must be cognizant of the potential judicial implications of the information coming from disease surveillance systems, especially with respect to governments themselves. An example was given of a particular case where a farm was identified as the source of a specific food contamination. The farmer contested this claim in court and sued the government. Because testing results did not provide unequivocal proof of the contamination source, the government lost the case. Consequently, the government was more hesitant in its response to subsequent disease outbreaks. It was contended that incidents of this kind undermine the future value of disease surveillance and that safeguards must be put into place to protect both parties' interests.

It was generally agreed that training of a new generation of professionals, including animal disease specialists, is a key component in the development of sustainable disease surveillance systems. Even though it is widely recognized that increasing the number of individuals who are well trained in both animal and human health practices is important, care must be taken not to train people without giving proper consideration to the availability of sustainable jobs. The success of the Cuban model of sending veterinarians to villages to develop local expertise was noted as an example to emulate. The issue of gender diversity in disease surveillance education was also raised. Since women are the primary animal caretakers in many areas of the world, it is appropriate that women receive better education in general and access to training programs (e.g., via outreach initiatives) to facilitate both better animal health practices and animal disease surveillance.

The importance of understanding social, behavioral, and cultural factors related to animal diseases and human health was raised on numerous occasions. For example, it was contended that if risks concerning bushmeat consumption are to be addressed and if people are to change their behaviors regarding hunting, better understanding is needed with respect to the cultural and social factors driving the perceived value of bushmeat as a food source (e.g., hunger and preference). It was argued that research through the social sciences would help clarify these issues.

Since countries lacking effective disease surveillance infrastructure may not welcome input from other countries, regardless of its positive intent, considering different models of delivering external support that transcend local cultures would be prudent. The notion of sending "SWAT"-style teams into affected areas was dismissed as inappropriate because it would not provide sustainable services. Attention was drawn to the methods used by the U.S. Department of Defense (DoD) overseas laboratories in successfully responding to zoonotic and animal disease outbreaks. These laboratories offer broad-based capabilities to host countries, but avoid imposing on the host countries' priorities by waiting until those countries solicit help. This form of coordination would provide useful training opportunities to areas where surveillance is currently subpar.

## Biographical information of scientific presenters

**Dr. Robert E. Brackett, Ph.D., M.S.**

Dr. Robert Brackett is Director and Vice President of the National Center for Food Safety and Technology (NCFST) at Illinois Institute of Technology (IIT). Dr. Brackett has nearly 30 years of experience in scientific research in industry, government, and academia. His work has focused primarily on the areas of food safety, defense, and nutrition. Prior to his post at NCFST, he served as Senior Vice President and Chief Science and Regulatory Officer for the Grocery Manufacturers Association (2007 to 2010); was Director of the U.S. Food and Drug Administration's Center for Food Safety and Applied Nutrition (FDA CFSAN), and held professorial positions within North Carolina State University (Raleigh) and the University of Georgia. Dr. Brackett is a fellow in the International Association for Food Protection and American Academy of Microbiologists, and a member of the International Association for Food Protection, Institute of Food Technologists, and the American Society for Microbiology. He has been honored with the FDA Award of Merit, the International Association for Food Protection's President's Appreciation Award, and the William C. Frazier Food Microbiology Award.

**Dr. Radford G. Davis, D.V.M., M.P.H., Diplomate A.C.V.P.M.**

Dr. Radford Davis is an Associate Professor in the Department of Veterinary Microbiology and Preventive Medicine at Iowa State University's College of Veterinary Medicine. He also is an instructor of public health, zoonoses, and epidemiology at Des Moines University. Prior to these posts, Dr. Davis was Adjunct Assistant Professor in the Department of Epidemiology at the University of Iowa's College of Public Health. Additionally, he was Assistant Director of the Center for Food Security and Public Health in the Department of Veterinary Microbiology and Preventive Medicine and Adjunct Assistant Professor of Public Health within the College of Veterinary Medicine at Iowa State University. Dr. Davis has been involved in numerous professional activities that include: service on multiple committees of the American Association of Veterinary Medical Colleges; Trainer for Mississippi State Animal Response Teams; service on the Editorial Review Board for Clinician's Brief, a peer-reviewed veterinary journal, and reviewer of books on topics related to veterinary medicine.

**Dr. Duane J. Gubler, Sc.D., M.S.**

Dr. Duane Gubler is Director of the Asia-Pacific Institute for Tropical Medicine and Infectious Diseases; Professor and Director of the Program on Emerging Infectious Diseases at Duke-

National University of Singapore (NUS) Graduate Medical School; and former Chair of the Department of Tropical Medicine, Medical Microbiology and Pharmacology at the University of Hawaii's John A. Burns School of Medicine. In Southeast Asia, he established the first virologic surveillance program for dengue hemorrhagic fever. In addition, Dr. Gubler served as Director of the Division of Vector-Borne Infectious Diseases, National Center for Infectious Diseases, Centers for Disease Control and Prevention (CDC), as Chief of CDC's Dengue Branch, and on numerous World Health Organization (WHO) committees. Dr. Gubler also coordinated emergency response efforts to vector-borne disease epidemics, including many dengue epidemics, the global response to the 1994 plague epidemic (India), the 1999–2004 West Nile virus epidemic (U.S./ Western Hemisphere), and the National Lyme Disease program (U.S.). He is a Fellow of the Infectious Disease Society of America, Fellow of the American Association for the Advancement of Science, and past President of the American Society of Tropical Medicine and Hygiene.

**Dr. Peter Hotez, M.D., Ph.D.**

Dr. Peter Hotez is Distinguished Research Professor, and Walter G. Ross Professor and Chair of the Department of Microbiology, Immunology, and Tropical Medicine at The George Washington University (GWU) in Washington, D.C. Dr. Hotez also is President of the Sabin Vaccine Institute. Dr. Hotez' academic research focuses on vaccine development for a wide range of neglected tropical diseases around the globe. Dr. Hotez founded the Human Hookworm Vaccine Initiative (HHVI) at Sabin and was instrumental in creating the Global Network for Neglected Tropical Diseases. He is also the Founding Editor-in-Chief of *PLoS Neglected Tropical Diseases*. Dr. Hotez was elected into the Institute of Medicine of the National Academies in 2008, and was named President of the American Society of Tropical Medicine and Hygiene in 2010.

**Prof. Stephen S. Morse, Ph.D.**

Dr. Stephen Morse is Professor of Clinical Epidemiology at Columbia University's Mailman School of Public Health and Founding Director and Senior Resident Scientist of the Center for Public Health Preparedness. He is currently Director of PREDICT, a U.S. AID-funded project to develop a global warning system for newly emerging diseases. Previously, Dr. Morse was program manager for biodefense at the Defense Advanced Research Projects Agency (DARPA), Department of Defense, where he co-directed the Pathogen Countermeasures program and subsequently directed the Advanced Diagnostics program. Dr. Morse was chair and principal organizer of the 1989 NIAID/NIH Conference on Emerging Viruses, for which he originated the term and concept of emerging viruses/infections and served as a member of the Institute of Medicine/National Academy of Sciences' Committee on Emerging Microbial Threats to Health. He currently serves on the Steering Committee of the Institute of Medicine's Forum on Microbial Threats and the National Academy of Sciences' Committee on Future Biowarfare Threats. He was the founding chair of ProMED (the nonprofit international Program to Monitor Emerging Diseases) and was one of the originators of ProMED-mail, an international network inaugurated by ProMED in 1994 for outbreak reporting and disease monitoring using the Internet.

**Prof. Arthur L. Reingold, M.D., M.P.H.**

Dr. Arthur Reingold is Professor of Epidemiology and Head of the Division of Epidemiology at the School of Public Health, University of California, Berkeley (UCB). He is also Professor of Epidemiology and Biostatistics and Clinical Professor of Medicine at the University of California, San Francisco (UCSF). Prior to joining UCB, Dr. Reingold worked in the Centers for Disease Control and Prevention (CDC) Epidemic Intelligence Service. While working with the CDC, Reingold helped identify Legionnaires' disease and toxic shock syndrome. Dr. Reingold currently serves on the World Health Organization's Strategic Advisory Group of Experts on vaccines and vaccine policy; is Director of the California Emerging Infections Program, and is Director of the NIH Fogarty AIDS International Training and Research Program at the University of California, Berkeley/UCSF. Dr. Reingold was elected to the Institute of Medicine in 2003 and holds the inaugural Edward E. Penhoet Distinguished Chair in Global Public Health and Infectious Diseases at the UCB School of Public Health.

**Prof. Kennedy F. Shortridge, Ph.D., D.Sc. (Hon), C.Biol.**

Dr. Kennedy F. Shortridge is Emeritus Professor of The University of Hong Kong where he previously held the Chair of Microbiology. His pioneering work on the ecology of influenza viruses focused on the origins of pandemic human influenza viruses. Dr. Shortridge first identified the H5N1 virus in chicken in Hong Kong in 1997, the causative agent of the outbreak resulting in the deaths of six of 18 patients. This was the first time a purely avian influenza virus was recognized as causing respiratory infection and death in humans. Dr. Shortridge was involved in the decision to depopulate poultry across the Hong Kong SAR to prevent the spread of the virus to humans. The principles learned in the H5N1 investigation led to the quick response and elimination of the civet cat as the immediate major source of the SARS virus for humans in 2003. He was jointly awarded the highly prestigious Prince Mahidol Award in Public Health of 1998 for services to the global community in dealing with the H5N1 virus.

**Dr. Travis J. Taylor, Ph.D.**

Dr. Travis Taylor is a Science Officer at the Global Viral Forecasting Initiative. He has been involved in science policy, international disease surveillance, and national security for more than a decade. After receiving his Ph.D. in Virology from Harvard University, Dr. Taylor was selected as an American Association for the Advancement of Science (AAAS) Science and Technology Policy Fellow at the U.S. Department of Defense (DoD). At the DoD, Dr. Taylor served as a technical adviser for the Biological Threat Reduction Program and assisted the development of surveillance and research programs in the former Soviet Union. For the past five years, Dr. Taylor has provided technical expertise for the World Bank, the U.S. Department of State and the U.S. Department of Homeland Security. As an advocate of fusing emerging technologies and the One Health model, he has traveled the world developing strategies for resource-poor countries to detect and respond to diseases.

**Dr. Madeleine C. Thomson, Ph.D.**

Dr. Madeleine C. Thomson is a senior research scientist at the International Research Institute for Climate and Society (IRI), the Earth Institute, Columbia University, where she directs Impacts Research, chairs the Africa Regional Program and supports the IRI-PAHO-WHO collaborating center activities. She trained originally as a field entomologist and has spent much of her career engaged in operational research in support of large-scale health interventions, mostly in Africa. Her research focuses on improving the understanding of the impact of climate variability and change on health outcomes and on the development of new tools for improving climate-sensitive health interventions. Dr. Thomson has been instrumental in the formation of a

WHO-led international research and operational partnership, Meningitis Environmental Risk Information Technologies. As a member of the MERIT Steering Committee she has been working with international, regional, and national organizations to improve the understanding of the climatic and environmental determinants of meningococcal meningitis and to use this information to improve prevention and control programs. She has become increasingly interested in improving institutional and human capacity for incorporating climate information into public health decision-making.

**Dr. Nathan Wolfe, D.Sc., M.A.**

Dr. Nathan Wolfe is Lorry I. Lokey Visiting Professor in Human Biology at Stanford University, and is the founder and Director of the Global Viral Forecasting Initiative (GVFI), a pandemic early warning system which monitors the spillover of novel infectious agents from animals into humans. He is also an adjunct Professor at Johns Hopkins University's Bloomberg School of Public Health. He formerly held the posts of full Professor at University of California Los Angeles and Assistant Professor at Johns Hopkins. He has extensive consulting experience on projects such as the Verona FAO-OIE-WHO joint technical consultation on Avian Influenza at the Human-Animal Interface, the University of California Los Angeles-University of North Carolina Democratic Republic of the Congo Monkeypox project, the U.S. Military HIV Research Program, and the International AIDS Vaccine Initiative. Dr. Wolfe has also served on numerous advisory and editorial boards, including the editorial board of EcoHealth, DARPA's Defense Science Research Council (DSRC), and the Mountain Gorilla Veterinary Project. He was awarded a Fulbright fellowship in 1997, the National Institutes of Health (NIH) International Research Scientist Development Award in 1999, and the NIH Director's Pioneer Award in 2005.

## Biographical information of ISGP staff

**George Atkinson, Ph.D.**

Dr. George Atkinson is the founder and the Executive Director of the ISGP and remains Professor of Chemistry, Biochemistry and Optical Science at the University of Arizona. His professional career spans several diverse arenas: academic teaching, research and administration, corporate founder and executive, and public service at the Federal level. He is former Head of the Department of Chemistry at the University of Arizona, the founder of a high-technology laser sensor company serving the semiconductor industry, and Science and Technology Adviser (STAS) to U.S. Secretaries of State Colin Powell and Condoleezza Rice. Notably, Dr. Atkinson also launched the Institute on Science for Global Policy (ISGP) in January 2008. The concepts and principles used by Dr. Atkinson to develop the ISGP derived from his personal experiences in domestic and international science policy. He seeks to guide the ISGP in creating a new type of international forum in which credible global experts provide governmental and societal leaders with the objective understanding of the science and technology (existing, emerging, and "at-the-horizon") now critically needed to formulate sound policy decisions. These are the S&T issues that can be reasonably anticipated to shape the increasingly global societies of the 21st century. His academic and professional achievements have been recognized in numerous ways including a Senior Fulbright Fellowship, an SERC Award (U.K.), the Senior Alexander von Humboldt Award (Germany), a Lady Davis Professorship (Israel), the first American Institute of Physics' Scientist Diplomat Award, the Distinguished Service Award (Indiana University), an Honorary Doctorate (Eckerd College), the Distinguished Achievement Award (University of California, Irvine), and selection by students as the Outstanding Teacher at the University of Arizona. He received his B.S. (high honors) from Eckerd College and his Ph.D. in physical chemistry from Indiana University.

**Jennifer Boice, M.B.A.**

Jennifer Boice is the Program Manager of the ISGP. Prior to this role, Ms. Boice worked 25 years in the newspaper industry, primarily at the Tucson Citizen and briefly at USAToday. She was the Editor of the Tucson Citizen when it was closed in 2009 by its parent company, Gannett Corp. Additional appointments at the Tucson Citizen included Business News Editor, Online Department Head, Senior Editor, and she was a columnist. Ms. Boice received an MBA from the University of Arizona and graduated from Pomona College in California with a degree in economics.

**Alexis Boyd, M.Sc.**

Alexis Boyd is a Senior Fellow with the ISGP. In addition, she is currently pursuing her Ph.D. in the Institute of Biomedical Sciences, Department of Microbiology and Immunology at The George Washington University. Her research is focused on the immune response to helminth parasites. Previously, Ms. Boyd was an Infectious Disease Training Fellow at the Centers for Disease Control and Prevention in the Division of Parasitology. She received her M.Sc. in Public Health Microbiology from the The George Washington University and majored in Biotechnology at Rutgers University.

**Christine Boyd, M.Sc.**

Christine Boyd is a Senior Fellow with the ISGP, as well as a teacher. Previously, Ms. Boyd was an intern at Roche in the Biochemistry and Drug Metabolism Department working on specificity studies for cytochrome-P450. As a graduate fellow at the National Institutes of Health (NIH), she worked on the development of a high pressure liquid chromatographic system for the separation of polycyclic aromatic hydrocarbons. She also worked with DNA repair and cell cultures at both the University of California-Irvine and at the University of Cincinnati. Ms. Boyd holds a M.Sc. in zoology.

**Melanie Brickman Stynes, Ph.D., M.Sc.**

Melanie Brickman Stynes is a Senior Scientist with the ISGP. As a researcher focused on the juncture of public health, demography, policy, and geography, she bridges multiple fields in her emerging and persistent infectious diseases research. Her work has paid particular attention to issues surrounding tuberculosis control (historic and contemporary). Additionally, Dr. Brickman Stynes spent nearly a decade as a Research Associate for the Center for International Earth Science Information Network (CIESIN) of Columbia University where she worked on a range of projects related to health, disease, poverty, urbanization, and population issues. She received her Ph.D. in medical geography from University College London and her M.Sc. in medical demography from the London School of Hygiene and Tropical Medicine.

**Jill Fromewick, Sc.D., M.S.**

Jill Fromewick is a Senior Fellow with the ISGP. A social epidemiologist by training, Dr. Fromewick maintains a dual focus on quantitative and qualitative methods. Her research spans a broad range of public health topics, primarily focused on investigating the impact of state and local policy on health and health disparities. She is co-founder and Senior Partner of Summit Research Associates, an international public health consulting firm specializing in program planning, evaluation, and social science research. Dr. Fromewick holds Masters and Doctor of Science degrees from Harvard School of Public Health's Department of Society, Human Development and Health with concentrations in social epidemiology, social policy, and analytic methods.

**Gill Green, Ph.D., M.A.**

Gill Green is a Consultant to the ISGP. Dr. Green is currently evaluating the model that underpins the ISGP program through a series of qualitative interviews with conference presenters and attendees. She is also a Clinical Psychologist with U.K. based ORConsulting Ltd. Dr. Green's focus is on the practical application of psychology in complex settings. She has worked across a range of global industries focusing on leadership development, team performance and wider organization change. She received her Ph.D. in Clinical Psychology from the University of Cardiff and an M.A. in Child Development from the University of Nottingham.

**Brendan Lee, D.V.M, M.Sc., M.P.H, D.A.C.V.P.M.**

Brendan Lee is a Senior Fellow with the ISGP and a Research Fellow with the National Center for Food Protection and Defense at the University of Minnesota. After practicing clinical veterinary medicine for several years, he turned his focus to public health and food safety. Currently, his primary focus is on issues surrounding food safety, global food systems, and zoonotic diseases, with an emphasis on developing countries. He received his D.V.M. from the University of The West Indies, his M.Sc. in Veterinary Epidemiology and Public Health from the University of London, and his M.P.H. from the University of Minnesota.

**Robert McCreight, Ph.D.**

Robert McCreight is a Senior Fellow with the ISGP. After 35 years serving the U.S. State Department and other federal agencies, Dr. McCreight retired in 2004 and served as a consultant for major homeland security and national defense contractors. His professional career includes work as an intelligence analyst, treaty negotiator, arms control delegate to the U.N., counter-terrorism advisor, and political-military affairs analyst. He spent 27 years of combined active and reserve military service concurrently with his civilian work in U.S. Army Special Operations and has devoted ten years to teaching graduate school. He received his Ph.D. from George Mason University and his M.A. from George Washington University.

**Arthur Rotstein, M.S.J.**

Arthur Rotstein is the Media Coordinator for the ISGP. Prior to joining the ISGP, Mr. Rotstein worked for the Washington D.C. Daily News, held a fellowship at the University of Chicago, and spent more than 35 years working as a journalist with The Associated Press. His writings have covered diverse topics that include politics, immigration, border issues, heart transplant and artificial heart developments, Biosphere 2, college athletics, features, papal visits, and the Mexico City earthquake. Mr. Rotstein holds a M.S.J. from Northwestern University's Medill School of Journalism.

**Raymond Schmidt, Ph.D.**

Ray Schmidt is a Senior Fellow with the ISGP. In addition, he is a physical chemist/chemical engineer with a strong interest in organizational effectiveness and community healthcare outcomes. While teaching at the university level, his research focused on using laser light scattering to study liquids, polymer flow, and biological transport phenomena. Upon moving to the upstream petroleum industry, he concentrated on research and development (R&D) and leading multidisciplinary multi-company teams to investigate future enhanced oil recovery ideas and to pilot/commercialize innovative recovery methods in domestic and foreign locations. Dr. Schmidt received his Ph.D. in chemistry from Emory University.

**Merlyn (Merle) Schuh, Ph.D.**

Merle Schuh is a Senior Fellow with the ISGP. Previously, Dr. Schuh spent most of his academic career at Davidson College, where he was the James G. Martin Professor of Chemistry and served eight years as department chair. His primary research interests have included: gas phase photophysics and UV-Vis spectroscopy, the use of fluorescence, phosphorescence and circular dichroism to study the folding/unfolding of globular proteins, and phosphorescent molecular cyclodextrin complexes for use in understanding intermolecular recognition and in developing molecular sensors. Dr. Schuh also has extensive teaching experience and is the recipient of numerous awards. He received his Ph.D. from Indiana University in physical chemistry.

**Tim Stephens, M.A.**

Tim Stephens is a Senior Fellow with the ISGP and, in addition, is the Public Health Advisor to the National Sheriffs Association. Mr. Stephens has been a public health administrator for twenty years, working on national and international public health preparedness and education programs. He received his M.A. in Communications from the University of North Carolina.