Human Diseases—Still Emerging, Still Dangerous

This year the public health community has been shaken by the emergence of a seemingly endless list of new human infections, reminding us that new human pathogens are not just a thing of the past.

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The threat of new and reemerging diseases was first outlined in the 1992 Institute of Medicine Report *Emerging Infections* and reiterated in its 2003 report *Microbial Threats to Health*. The 1992 report included these factors of emergence: demographics and behavior change; changes in land use, technology, trade, and travel; microbial adaptation and change; and the breakdown in public health. These factors were expanded in the 2003 report to include climate change, harmful intent, and the gap between the rich and poor of the world. The importance of these factors in putting populations at risk of new diseases has been demonstrated repeatedly over the past decade with outbreaks such as HIV/AIDS and SARS. (*See page 4 for a list of some of the microbes and diseases recognized since 1977.*)

How do new human infections arise and enter our populations? This question really has two parts: where do such new agents originate? and how do they get transmitted around the globe?

How do new diseases arise?

The outlining of the factors of emergence by the National Academy's expert group is essentially an intuitive process. To date, no published empirical studies test the hypothesized relationship of a given factor to the occurrence of a new infection.

Historically, new human infections come from other vertebrates. HIV/AIDS is now believed to have hopped the species barrier between simians (monkeys and their relatives) and humans sometime in the 1930s. The infection, which was not highly communicable, remained at a low level until political chaos, warfare, and massive population displacements in Central Africa in the early 1980s enhanced its amplification in populations there. Travel and trade in blood products promoted distribution around the globe.

Emerging infections are those whose incidence in humans has increased within the past two decades or threatens to increase in the near future. Emergence may be due to the spread of a new agent, to the recognition of an infection that has been present in the population but has gone undetected, or to the realization that an established disease has an infectious origin. Emergence may also be used to describe the reappearance (or "reemergence") of a known infection after a decline in incidence.

—*Emerging Infectious Diseases: Microbial Threats to Health in the United States*, Institute of Medicine, 1992

Another example, SARS, is a coronavirus, believed to have hopped species from either the palm civet cat or a species of rat. The studies on its origin are conflicting. But what is notable is that when this outbreak occurred, the "human health" experts knew little about the Coronavirus family, since this is, historically, a minor pathogen for humans. However, the veterinary experts knew a great deal more; disease due to Coronaviridae is an important cause of morbidity in animals. In the wake of such infections as SARS, the importance of linkages between animal and human medicine is very clear.

An even more recent example is avian influenza, which in late 2003 and early 2004 swept through a number of Asian countries. This outbreak of highly pathogenic avian influenza has produced a handful of human cases. With the emergence of avian influenza in Asia, and the threat of reassortment and human to human transmission, pandemic influenza planning has become urgent. Such a planning exercise under the auspices of the Asia Pacific Economic Cooperation is being developed through an international network run by the University of Washington.

Although influenza virus is tracked in more than 100 laboratories worldwide through the efforts of the World Health Organization, predicting the antigenic "shift" and "drift" of this RNA virus remains elusive. Strategies for population protection are limited and include isolation and quarantine, antiviral use at the first clinical signs of illness, and prophylactic vaccination. The United States strategy relies almost completely on annual vaccination of high-risk groups. The success of this approach hinges on annual reconstitution of the vaccine and administration of that vaccine to target population groups. In 2003 the exclusion of the circulating Fujian strain of flu compromised the success of vaccination efforts. A compounding problem is that the vaccine production and distribution is largely limited to Europe and North America.

How do they arrive here?

The question of how new infections get here is much more straightforward. SARS traveled by airplane, but it is not the first pathogen to do so. Measles importations occur frequently, and multidrug tuberculosis and influenza have also been spread aboard aircraft. But pathogens travel in all transportation modes. An unseasonable outbreak of influenza with an unusual strain, for example, was brought to Alaska on a cruise ship by tourists from Australia. It is important to remember that trade in commodities can actually be one way animals "travel"; products derived from animal and human material can convey and amplify infection. For example, Japan cites the global trade in blood products as the source of its HIV disease.

The gap in science

How does the macro (climate, demographic changes, and so on) influence the micro (viruses, for example) in provoking these emergent outbreaks? What mechanisms are at work, for example, that translate the changes in animal husbandry and beef processing in the United Kingdom into the emergence of a prion disease such as mad cow (bovine spongiform encephalopathy)? Despite a decade of description about how these epidemics occur, the basic knowledge base that would allow public health to prevent their emergence still seems to lag.

An example will illustrate this gap. The consolidation of meat processing in the United States resulted in the gathering, in feed lots, of unprecedented numbers of cattle who traveled longer distances to reach slaughtering facilities. Because cattle are not fed before slaughter, the combination of crowding and starving probably increased the shedding of and cross infection of animals with *E. coli* O157H7. The mechanization of slaughter, trimming, and packing of beef, with a larger volume of infected material moving through processing at a faster rate, probably contributed to the eventual appearance of *E. coli* O157H7 as a major human epidemic pathogen in 1997 in Washington State. The outbreak detected in Washington was actually part of a five-state outbreak that was not picked up by surveillance in the other four states.

We know the path the outbreak followed, but exactly how the emergence of *E. coli* O157H7 occurred as a new pathogen in humans remains obscure. What mechanisms at the molecular level may have been involved in the evolution of the human pathogenicity of the organism? What is the "tipping point" after which consolidation of the processing of animal material becomes risky? Should a limit be placed on such consolidation, and if so, what metrics would be followed in defining such a limit? Public health would do well to link seriously with food science and veterinary medicine, among other disciplines, to begin to develop a research agenda to answer these questions. Why? Without answers, a primary prevention agenda for food safety cannot be scientifically tailored to prevent the emergence of new human pathogens.

Factors of Emergence Revisited

Various factors contribute to the emergence or reemergence of diseases and infections. Among those factors are:

- Microbial adaptation and change
- Human demographics and behavior
- International travel and commerce
- Human susceptibility to infection
- Poverty and social inequality
- Breakdown of public health
- Economic development and land use
- Climate and weather
- Changing ecosystems
- Technology and industry
- War and famine
- Lack of political will
- Intent to harm

Public health responds

As the response to SARS illustrated, public health practice has relied on old tools for containment when faced with an outbreak of a new, unknown infection. But SARS also demonstrated the power of public health's new communication, networking, and modeling tools. Now public health authorities can communicate their experience with a new infection more rapidly than ever using e-mail and the Internet.

The University of Washington's international network of public health and commerce authorities in the Asia Pacific demonstrates the kind of deliberate networking that is important for planning and preparedness for responses to epidemics. In addition, modern modeling techniques allow the rapid determination of the reproductive rate of an epidemic if good quality epidemiologic field data are available, so the characteristics of an agent—for example, its contagiousness—can be known early in an event and shared across outbreak locations.

The response to public health emergencies such as SARS has given policy makers insight into the need to extend preparedness planning, partnerships, and practice beyond a narrow focus on bioterrorism. Public health authorities need to incorporate planning for emerging infections into their biopreparedness plans at every opportunity. If we think of SARS and avian influenza as "shots across the bow" of public health, it is time to ensure a sound course to avoid a more serious engagement.

Resources

Asia-Pacific Economic Cooperation, Regional Health Threats. http://apec.org/apec/apec_information_on.html.

Emerging/Reemerging Diseases (PAHO). www.paho.org/english/ad/dpc/cd/eid-eer.htm.

Health and Borders: Comparing global to international & local visions of health and disease. http://caribou.cc.trincoll.edu/~jtrostle/main.html.

The United States Army Medical Research Institute for Infectious Diseases - USAMRIID. www.usamriid.army.mil/index.html.

World Health Organization. Strategies for Fighting Emerging/Reemerging Diseases: Preparedness and Response Plans. www.who.int/csr/delibepidemics/en/Preparednessproject.pdf .

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