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Regulating Viral Traffic

Emerging diseases are usually not "new," just freed from obscurity by acts of man. With some government investment, we can contain them.

The human immunodeficiency virus—the AIDS virus—has been front-page news so steadily that it is hard to remember that it appeared only within the past decade.

But HIV is not the only virus that has lately gained attention. In recent months, the feared Ebola virus made an unanticipated appearance in monkeys imported into the United States from Africa and Asia, and several American technicians who handled the monkeys apparently became infected. The incident is an example of history repeating itself: Ebola's relative, the Marburg virus, was the first member of this virus family to be identified when, in 1967, 25 laboratory workers in Germany and Yugoslavia contracted it from handling infected monkeys. Although the European incident resulted in seven deaths, the recent American outbreak fortunately has not yet claimed any lives. However, the Ebola virus is feared for good reason: It was first encountered as the cause of a 1976 epidemic in Zaire with 500 reg-Iistered cases and mortality rates exceeding 70 percent.

Such regularly occurring experiences seem to justify the impression that we are being bombarded with new infectious diseases. And they reinforce a general feeling that sudden disease outbreaks will emerge in capricious ways as "acts of God." Even among scientists, the factors responsible for unforeseen epidemics of diseases such as AIDS, and even of familiar diseases such as influenza, have been poorly understood.

But although virologists cannot yet predict specific disease outbreaks, we now understand many of the factors leading to them. And because we have a better grasp of their origins, for the first time we are in a position to do something about emerging diseases at fairly early stages.

Viral highways and byways

Despite appearances, "emerging" viruses are usually not newly evolved organisms. The overwhelming

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majority are existing viruses that are conquering new territory as they gain access to new host populations, most often through acts of man. Such movements of viruses to new species or new individuals I call "viral traffic."

A variety of human activities can precipitate viral traffic, but some types of activities—such as the introduction of, or changes in, certain types of agricultural practices—appear especially likely to do so. For example, Hantaan virus, the cause of Korean hemorrhagic fever, first came to Western attention when U.S. and UN peacekeeping troops in Korea succumbed to the disease. But it has been known in Asia for centuries and is currently responsible for over 100,000 cases a year in China. The virus is a natural infection of the striped field mouse, *Apodemus agrarius,* which flourishes in rice fields; people usually contract the disease during the rice harvest.

Junin virus, the cause of Argentine hemorrhagic fever, is an unrelated virus with a history remarkably similar to that of Hantaan. Conversion of grassland to maize cultivation in Argentina favored the rodent that was the natural host for this virus, and human cases increased as agriculture expanded.

The most startling example of the effect of human actions on viral spread is pandemic influenza, which appears to originate in integrated pig-duck farming in China. Strong evidence amassed by Robert G.Webster (of the St. Jude Children's Research Hospital in Memphis), Christoph Scholtissek (of the Institut für Virologie at Justus Liebig University in Giessen, West Germany), and other influenza virologists indicates that waterfowl such as ducks are major reservoirs of influenza and that pigs can serve as reassorting or "mixing vessels" for new mammalian influenza strains. Integrated pig-duck agriculture, an extremely efficient food production system practiced in China for several centuries, puts these two species—and humans—in close contact and provides a natural laboratory for making new influenza recombinants.

This is startling information because influenza has always been described as the classic example of viral evolution at work, and scientists have long believed that new epidemics are caused by mutations in the virus. Although this may be true of the smaller annual or biennial epidemics we frequently experience, it is apparently not true of the influenza viruses that cause pandemics.

Insect-transmitted viruses—for example, those that cause such notorious diseases as dengue fever and yellow fever—are often stimulated by expansion of open water supplies, which provide the insects' breeding ground. For example, outbreaks of Rift Valley fever in some parts of Africa have been associated with dam building or heavy rainfall. Thomas Lovejoy (of the Smithsonian Institution) has cited the case of Lake Bayano in Panama, whose creation as part of a hydroelectric project caused a local increase in cases of Venezuelan equine encephalomyelitis, another serious mosquito-borne viral disease.

Human actions may disseminate vectors as well as viruses. Both yellow fever virus and its principal vector, the *Aedes aegypti* mosquito, are believed to have been spread from Africa via the slave trade. The mosquitoes were stowaways in the large open jars of water kept on the ships for the human cargo. More recently, the Asian tiger mosquito, an aggressive vector of dengue virus, was introduced into the United States in water puddles inside used tires shipped from Asia. From its 1985 entry in Houston, Texas, the mosquito has established itself in at least 17 states.

Inevitably, viral traffic is enhanced by *human* traffic. Highways and the subsequent human migration to cities, especially in topical areas, can introduce once-remote viruses to a larger population. On a global scale, similar opportunities are offered by rapid air travel. The U.S. Public Health Service reported 124 suspected cases of dengue fever in 1988, brought in by travelers returning from other countries.

Virus tracking centers

Knowledge of viral traffic can help us identify where to look and what to look for, but only if mechanisms are in place to deepen this knowledge and help put it into action.

A comprehensive plan was recently put forward by D.A.Henderson of Johns Hopkins University, who earlier spearheaded the highly successful international smallpox-eradication program. He proposes to establish a network of international centers to detect the emergence of dangerous diseases and, if possible, to contain them.

Centers would be located in tropical areas, especially near cities; each center would include diagnostic and research laboratories, an epidemiological unit that could perform disease investigation and lead a local

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response, a professional training unit, and treatment facilities. Each center would be part of an international network—including academic and government laboratories—in order to coordinate data collection and evaluation, conduct relevant research, provide back-up support, and activate an international rapid response system when warranted.

Ironically, although agriculturists have often bemoaned the inadequacy of present systems for agricultural research, it is far ahead of medical science. Henderson has in fact modeled his center concept on the network of laboratories in the Consultative Group on International Agricultural Research (CGIAR). The proposed network could even be interfaced with CGIAR, which includes the International Laboratory for Research on Animal Diseases in Kenya. A joint network of animal and human health research centers, operating internationally and combining efforts when appropriate, would make great sense scientifically as well as economically.

Henderson estimates the initial cost of his program to be $150 million a year, which would support 15 overseas centers plus 10 supporting labs in the United States. He notes that this is roughly equivalent to the annual costs of smallpox control measures before the disease's global eradication.

Actually, worldwide disease-surveillance and research networks were successfully tested for decades, but we failed to sustain several promising programs. For example, the Rockefeller Foundation established a number of virology laboratories worldwide in the 1950s and 1960s, principally in developing countries. Each facility was seen as a collaboration between Western and Third World colleagues, with an emphasis on developing local capabilities, local autonomy, and national pride. At the same time, specialized laboratories in the United States, such as what is now the Yale Arbovirus Research Unit, supplied training and support. Much of our present knowledge of viral ecology was acquired as a result of this effort, and most of the over 500 known arthropod-borne viruses (derived from insects and ticks) were discovered as a result of this program (despite the primitive technology that was then available). Unfortunately, the Foundation's support was phased out in the 1970s and most of the labs no longer exist.

The United States should play a major role in correcting this situation—we have long been a principal player in international health—but first we need to get our own house in order. Federal responsibilities for international disease surveillance and health programs are currently fragmented and diffuse. The numerous agencies involved in different aspects of international disease prevention include the Centers for Disease Control, the National Institutes of Health, portions of the Department of Defense, and the Agency for International Development, but no federal agency has the responsibility to track foreign outbreaks of human diseases, and none is adequately funded for this purpose.

Meanwhile, though no agency charts on a worldwide basis the emergence of virus outbreaks in humans, the U.S. Department of Agriculture is required to track foreign diseases of livestock and prevent them from reaching our shores. The USDA does this conscientiously, despite limited resources, thereby demonstrating that tracking virus outbreaks is feasible—and can be done on a reasonable budget.

Obviously, one of the first priorities in establishing a disease surveillance network should be the coordination of current federal efforts. One approach would be an interagency working group, perhaps organized under the aegis of the Public Health Service.

An adjunct to development

More generally, officials of all kinds—not only in the health field—need to be aware of the infectious-disease implications of ecological and demographic changes. These are "signals" for viral traffic, and we must concentrate attention and resources in the areas where they occur.

Thus "Viral traffic planning" should be an adjunct to development plans. Development agencies should be educated to include emerging-virus considerations when evaluating major changes in land use or when making decisions that will alter ecological equilibria or population densities. It may even be possible to develop regular "viral impact assessments" analogous to environmental impact assessments, for projects or events likely to involve such changes.

More immediately, we can make more effective use of measures we already have at our disposal, such as water resources development (to reduce open storage of water) and insect control, that were developed for other purposes. And although we tend to think in terms of massive projects, public education on basic precautions, such as eliminating puddles or controlling rodents, can make a big difference. For example, while the impact of the previously mentioned Argentine hernorrhagic fever is still increasing, Bolivian hemorrhagic fever is on the wane: Local programs have dramatically reduced the numbers of infected rodents.

The problem of emerging viruses is not likely to disappear. If anything, it will worsen; episodes of seemingly new viral diseases are likely to become more frequent as environmental change accelerates. At the same time, rapid transportation and increasing urban density will continue to enhance the dissemination of previously localized viruses. And although I have concentrated on viruses in this article, the same mechanisms appear responsible for most emerging infectious diseases, both in the tropics and closer to home. The recent emergence of Lyme disease in the northeastern United States, for example, is also very likely due to environmental changes—in this case, in the density of wooded land around homes.

Emerging infectious disease is just one more consequence of ecological damage. But addressing the problem could provide common ground for uniting otherwise diverse interests—environmental, agricultural, economic, and health—to simultaneously address a wide range of other concerns as well.

Recommended reading

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