Hot spots in a wired world: WHO surveillance of emerging and re-emerging infectious diseases

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The resurgence of the microbial threat, rooted in several recent trends, has increased the vulnerability of all nations to the risk of infectious diseases, whether newly emerging, well-established, or deliberately caused. Infectious disease intelligence, gleaned through sensitive surveillance, is the best defence. The epidemiological and laboratory techniques needed to detect, investigate, and contain a deliberate outbreak are the same as those used for natural outbreaks. In April 2000, WHO formalised an infrastructure (the Global Outbreak Alert and Response Network) for responding to the heightened need for early awareness of outbreaks and preparedness to respond. The Network, which unites 110 existing networks, is supported by several new mechanisms and a computer-driven tool for real time gathering of disease intelligence. The procedure for outbreak alert and response has four phases: systematic detection, outbreak verification, real time alerts, and rapid response. For response, the framework uses different strategies for combating known risks and unexpected events, and for improving both global and national preparedness. New forces at work in an electronically interconnected world are beginning to break down the traditional reluctance of countries to report outbreaks due to fear of the negative impact on trade and tourism. About 65% of the world's first news about infectious disease events now comes from informal sources, including press reports and the internet.
Lancet Infectious Diseases 2001; **1:** 345–53

The control of infectious diseases has always been a core function of the WHO, though with varying degrees of importance. In 1949, infectious diseases dominated the new agency's first list of priorities where governments felt international action was urgently needed: malaria, tuberculosis, and sexually transmitted diseases.[1] In the ensuing decades, these and a growing number of other infectious diseases were attacked with great optimism, supported by the promise of powerful new antibiotics, vaccines, and insecticides.[2] Mass campaigns using penicillin were launched against syphilis and the endemic trepanematoses with encouraging results. Malaria was eliminated from many areas by the systematic application of insecticides and removal of mosquito breeding sites. As standards of living improved and effective drugs became available, tuberculosis receded as a threat in many advanced countries. On the eve of its 20th anniversary, WHO expressed the sanguine view that malaria was decreasing in importance as a disease of international significance, and that many others diseases, including tuberculosis, poliomyelitis, smallpox, yellow fever, typhoid fever, diphtheria, and pertussis, were successfully controlled and would gradually disappear.[3] The eradication of smallpox in the late 1970s bolstered this optimistic view considerably. WHO moved on to other priorities, ushered in by the Health for All movement, and eventually expanded its scope to include close to 50 health issues.

In 1999, the 52nd World Health Assembly asked the now established WHO to move away from this "full menu" approach and again concentrate its efforts on a limited number of priority threats including AIDS, malaria, tuberculosis, and tobacco.[4] While the similarity of the two agendas—separated by 50 years—masks considerable progress in many areas of health (the highest national life expectancy in 1949 was 70 years compared with 84·3 today), it does underscore an alarming trend. Infectious diseases have resurged to an extent that again merits the highest level of international concern. Moreover, the nature of this threat, in terms of numbers and geographical scope, has enlarged considerably.

Hot spots: emerging and re-emerging diseases

The microbial world is complex, dynamic, and constantly evolving. Microbes proliferate rapidly, mutate frequently, and adapt with relative ease to new environments and hosts. They also eventually develop resistance to the drugs used to treat them. Factors linked to a host of human activities can accelerate and amplify these natural phenomena. Moreover, when a complacent world relaxes its vigilance and lets down

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Figure 1. Emerging and re-emerging infectious diseases, 1996–2001. Infectious diseases once considered remote threats have emerged or re-emerged on every continent in recent years. Source: WHO, 2001.

its defences, the consequences can be rapid as well as dramatic. Microbes are quick to exploit new opportunities to spread, adapt, and resist.

The opportunities have been numerous. Some have their roots in demographic trends. The world's population more than doubled in the second half of the 20th century, accelerating most rapidly in the developing countries of the tropics and sub-tropics, where infectious diseases have long had their most tenacious hold.[5] Population growth, rural-urban migration, and the inadequacy of sanitation and other basic infrastructures have contributed to the resurgence of many diseases such as tuberculosis, cholera, typhoid, and plague that thrive on conditions of poor hygiene and overcrowding. Cholera, for example, has caused epidemics over the past decade in parts of Latin America where it had previously been reported only sporadically.[6] Countries in Africa and South America have seen a dramatic re-emergence of yellow fever since the 1980s.[7]

In wealthier parts of the world, microbes have been quick to exploit populations made vulnerable by poverty, illness, social marginalisation, or collapsing health systems. In New York City in the 1980s, multidrug-resistant strains of tuberculosis gained their hold in hospitals, prisons, and homeless populations.[8] Tuberculosis, including multidrug-resistant forms, took advantage of weakened infrastructures in countries of the former Soviet Union and re-emerged, with cases more than doubling in less than 7 years and with over 20% of patients in prison settings now infected with multidrug-resistant strains.[9] Epidemics of diphtheria returned to Russia and the Ukraine after the breakdown of immunisation in the early 1990s.[10]

Human invasion and disturbance of new ecological zones has increased the frequency with which diseases, previously confined to animals, cross the species barrier to infect people. Man-made changes, such as deforestation, disrupt natural habitats and can force animals, searching for food, into closer contact with people. Outbreaks of Lassa fever in west Africa and of hantavirus in North America have been linked to such phenomena.[11,12] In Latin America, Chagas disease emerged as an important human disease after mismanagement of deforested land caused triatomine populations to move from their wild natural hosts to involve human beings and domestic animals in the transmission cycle, eventually transforming the disease into an urban infection that can be transmitted by blood transfusion.[13] Climate extremes, whether involving excessive rainfall or drought, can likewise displace animal species and bring them into closer contact with human settlements, or increase vector breeding sites. A 1998 outbreak of Japanese encephalitis in Papua New Guinea has been linked to extensive drought, which led to increased mosquito breeding as rivers dried into stagnant pools.[14] The virus is now widespread in Papua New Guinea and threatening to move farther east. Though intensive research has failed to disclose the origins of Marburg and Ebola haemorrhagic fever outbreaks, both are thought to have animal sources somewhere in the transmission cycle.[15]

The consequences of interspecies transmission of pathogens are potentially most devastating in the case of

influenza viruses, where virologists believe that it is only a matter of time until a virus circulating in domestic animals establishes itself in the non-immune human population and causes the next highly lethal pandemic.[16] In this case, the most alarming recent opportunity arises from intensive farming practices that have placed people in close proximity to domestic animals in densely populated areas. In the Hong Kong Special Administrative Region of China, characterised by heavy international traffic, crowded conditions, and live poultry markets in close proximity to residential areas, a total of 18 cases of human infection with influenza A virus sub-type H5N1, previously confined to birds, occurred in 1997, causing six deaths and raising considerable alarm.[17] The virus meets two of the three criteria for a new virus capable of causing a pandemic: the ability to replicate in human beings, and the absence of antibodies to the virus in the human population at large. The third requirement, the potential for rapid spread among people, has not so far been demonstrated. Although human-to-human transmission of the virus was documented, it was found to be relatively inefficient and uncommon.[18]

Other new opportunities can be attributed to the world's relaxed vigilance and lapses in control. The collapse of programmes for vector control has encouraged diseases, such as dengue and yellow fever, to resurge and spread to new areas. After the deterioration of *Aedes aegypti* control campaigns during the 1970s, dengue resurged dramatically, with unprecedented numbers of its haemorrhagic form.[19] Before 1970, only nine countries had experienced epidemics of dengue. Since then the number has increased more than four-fold and continues to rise. The 1998 pandemic, in which 1·2 million cases were reported from 56 countries, was unprecedented. The resurgence of African trypanosomiasis, which began in the 1980s, likewise followed the decline of most surveillance and vector control activities.[20]

Vectors have also been quick to exploit new opportunities created by environmental degradation and human behavioural change. Epidemics of dengue and yellow fever have been fuelled by the adoption of modern consumer habits in urban areas of the developing world, where discarded household appliances, tyres, plastic food containers, and jars have created abundant artificial breeding sites. *Ae aegypti* is now well established in most, if not all, large African cities, greatly increasing the risk of explosive urban outbreaks.[21] In countries of the former Soviet Union, large amounts of stagnant water, created by ineffective irrigation schemes, encouraged the re-emergence of malaria in the most southern states, where a few incidental and probably imported cases in Tajikistan in the early 1990s multiplied to almost 20 000 reported cases in 1998.[9] Such problems are compounded by the very small number of new cost-effective chemical pesticides, suitable for public health, that have been developed in recent years.

Advances in food production and storage technology, coupled with the globalisation of markets, have resulted in a food chain that is unprecedented in its length and complexity, thus creating an efficient vehicle for pathogens to spread to new areas and susceptible hosts. Tracing the origin of all ingredients in a meal has become virtually impossible, constituting an enormous challenge for the control of foodborne diseases.[21] Medical advances in such areas as blood transfusion, organ transplantation, and other sophisticated surgical procedures, and the development of intensive care units, have likewise opened new opportunities for the microbial world, creating ideal conditions for nosocomial transmission of infectious agents to new, atypical hosts.[21]

As a result of these and other trends, the number of microbial threats, in the form of newly identified pathogens, diseases crossing the species barrier to people, diseases and vectors adapting to new environments, and diseases appearing in more virulent forms, has multiplied to an unprecedented degree.[22] New and newly recognised diseases are now being reported at the rate of about one per year. Altogether, at least 33 completely new pathogens, including HIV, have emerged during the past 3 decades.

The alarm created by these trends has been intensified by the unprecedented immediacy and widespread nature of the renewed microbial threat. The phenomenal growth of international travel and trade has vastly increased the speed with which pathogens, incubating in unsuspecting human beings and animals, and vectors, concealed in cargoes or in the luggage holds and cabins of jets, can cross continents, invade new territories, and set up residence. As a result, the threat of epidemic diseases, recently considered remote in most wealthy nations, has moved closer to home in every country. In recent years, every continent has experienced an unexpected outbreak of some infectious disease, from Lyme disease and West Nile fever in North America, to legionellosis, Lassa fever, and variant Creutzfeld-Jakob disease in Europe, to Hendra disease and legionellosis in Australia (figure 1). Moreover, once established on new continents, vectors, such as the Asian tiger mosquito in North America, and diseases, such as West Nile fever in North American and Rift Valley fever in the Arabian peninsula, have proved difficult if not impossible to remove.[23–26]

A post-antibiotic era?

On another front, resistance to inexpensive and effective antimicrobial drugs has emerged and spread at an alarming rate, raising the prospect that many common diseases could become prohibitively expensive or impossible to treat.[27] The bacterial infections that contribute most to human disease are also those in which emerging resistance is of most concern: diarrhoeal diseases such as dysentery, respiratory tract infections, including pneumococcal pneumonia and multidrug-resistant tuberculosis, sexually transmitted infections such as gonorrhoea, and a host of hospital-acquired infections that are notoriously difficult and expensive to treat. Among the major infectious diseases, the development of resistance to drugs commonly used to treat malaria is of particular concern, as is the emerging resistance to anti-HIV drugs. Most alarming of all are microbes such as *Staphylococcus aureus* and *Salmonella typhi* that have accumulated resistance genes to virtually all currently available drugs and have the potential to cause untreatable infections, thus raising the spectre of a post-antibiotic era. Even if the pharmaceutical industry were to step up efforts

Figure 2. Conditions during the Ebola outbreak in Uganda that began in October 2000. Poverty stricken countries that lack the epidemiological and laboratory capacity to detect and contain the spread of infectious diseases are most susceptible to outbreaks of emerging and epidemic-prone diseases.

to develop new drugs immediately, current trends suggest that some diseases may have very few and, in some cases, no effective therapies within the next 10 years.[27] Moreover, if current trends continue, many important medical and surgical procedures, including cancer chemotherapy, bone marrow and organ transplantation, and hip and other joint replacements, could no longer be undertaken out of fear that the associated compromise of immune function might place patients at risk of acquiring a difficult to treat and ultimately fatal infection. Opportunistic infections in AIDS patients would likewise become an especially difficult challenge.

The universal nature of the microbial threat, with agents of disease, including drug resistant forms, passing undetected across increasingly porous borders, has placed all nations on an equally vulnerable footing. The world is now interconnected in matters of health as well as economics and trade, with the result that distinctions between domestic and foreign health affairs have been eroded. In its landmark 1992 report, the US Institute of Medicine acknowledged that the microbial threat to health in a single nation could not be adequately addressed without considering emerging threats globally.[28] In 2000, perception of the growing infectious disease threat broadened to include global social, economic, political, and security implications.[29] The impact on health alone has been considerable. In 1999, the lower figure in the life expectancy range, which had seen a steady increase in previous decades, declined to 33·2 years, just above the 33 years seen in 1949, largely due to the emergence and spread of HIV.[30] Many spectacular gains in human health, linked to the progressive control of infectious diseases, are now likewise under threat.

The best defence: real time surveillance and response

In the volatile new milieu of emerging, adapting, and highly mobile pathogens, the best defence is good infectious disease intelligence, on a global scale, gleaned through sensitive surveillance. Surveillance systems keep the world alert to changes in the infectious disease threat and provide the background data needed to detect an unusual event, whether involving an upsurge in cases of a well-known endemic disease, the appearance of a previously unknown pathogen, or an outbreak caused by the deliberate use of a biological agent to cause harm. Because susceptibility to infectious diseases and the opportunities for infection rapidly increase with poverty, poverty remains the variable most frequently associated with the occurrence of infectious diseases.[21] Not surprisingly, outbreaks of both newly identified diseases and well-known epidemic-prone diseases occur most frequently in countries that lack the epidemiological and laboratory capacity to detect them quickly and contain their spread (figure 2). For this reason, continuing surveillance, supported by strengthening of national capacities, is further needed to keep the international community prepared to provide assistance, in the interest of defending global health security, whenever needed.

WHO has recently established an infrastructure for responding to this heightened need for awareness and preparedness. The infrastructure is supported by several new mechanisms and a computer-driven tool for real-time gathering of disease intelligence, and takes full advantage of powerful new opportunities created by the widespread use of electronic communications. Under development since 1997, the infrastructure was formalised in April 2000 when WHO launched the Global Outbreak Alert and Response Network.[31] The network interlinks, in real time, a large number of existing networks which together possess much of the data, expertise, and skills needed to keep the international community constantly alert and ready to respond. In just the past year, the number of participating networks has grown from 72 to 110.

The procedure for outbreak alert and response has four phases: systematic collection of reports or rumours of new outbreaks, outbreak verification, communication of confirmed facts to selected partners and the world at large, and containment, including coordination of international assistance when required. By electronically linking together existing networks, WHO is thus able to magnify its limited resources considerably.

Systematic detection

Both formal and informal sources of information are used to detect suspected outbreaks. Government and university centres, such as the US Centers for Disease Control and Prevention (CDC), the UK Public Health Laboratory Service, and the French Instituts Pasteur, provide confirmed reports of outbreaks to assist in the confirmation of

outbreaks. These and other centres are part of a network of over 250 laboratories and institutions formally designated as WHO collaborating centres. Additional formal sources include other UN agencies (notably United Nations High Commissioner for Refugees and Unicef), ministries of health, academic institutes, WHO regional and country offices, and government networks of overseas military laboratories, such as the US Department of Defense Global Emerging Infections System (GEIS).[32]

Of the informal sources, one of the most important is a semi-automated electronic system that continuously scours world communications for rumours of unusual disease events. This is the Global Public Health Intelligence Network (GPHIN) electronic surveillance system developed for WHO in 1997 in partnership with Health Canada.[33] GPHIN heightens vigilance by continuously and systematically crawling web sites, news wires, local online newspapers, public health email services, and electronic discussion groups, including the Programme for Monitoring Emerging Diseases (ProMED-mail) sponsored by the International Society for Infectious Diseases, for rumours of outbreaks.[34] In this way, WHO is able to scan the world for informal news that gives cause for suspecting an unusual disease event. Informal reports also come in from non-governmental organisations, such as the Red Cross and Crescent societies, Médecins Sans Frontières, and religious organisations, such as the Catholic and Protestant mission networks.

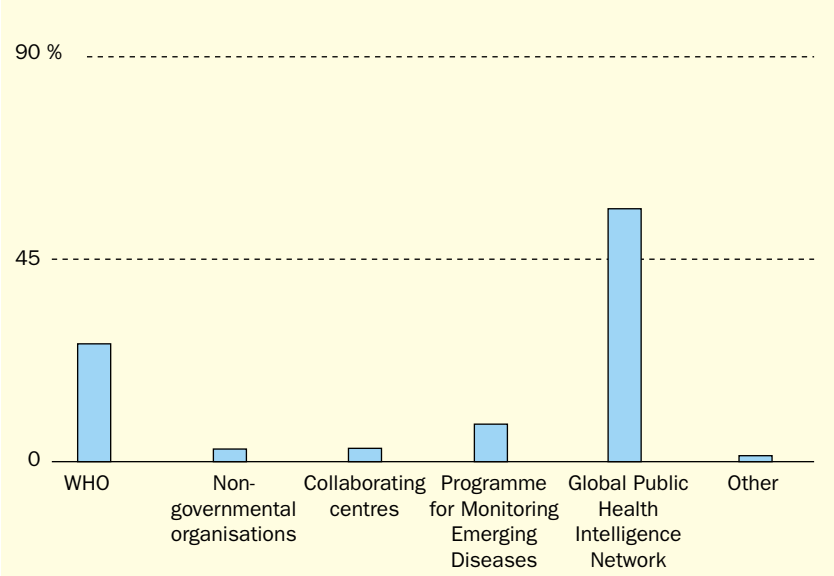

Figure 3. Initial source of reports of outbreaks 1998–2001. The Global Public Health Intelligence Network (GPHIN) computer application picked up the initial rumours of 56% of 578 outbreaks subsequently verified by WHO for the period July 1998 to August 2001. Source: WHO, 2001.

Outbreak verification

Raw intelligence gleaned from all formal and informal sources is converted into meaningful intelligence by the WHO Outbreak Verification Team, which meets daily to review incoming reports and rumours, assess their epidemiological significance, and decide on the actions needed. The team establishes the potential importance of the event on the basis of available background data, endemicity levels, and information on the evolution of previous outbreaks, when available. Four main criteria are used to determine whether an event is of potential international public health importance: serious health impact or unexpectedly high rates of illness and death, potential for spread beyond national borders, potential for interference with international travel or trade, and strength of national capacity to contain the outbreak.[35] Each event is assessed individually on the basis of these criteria. While some diseases such as Ebola haemorrhagic fever and cholera will almost invariably be recognised as important for international public health, others may not, depending on the circumstances. The team also routinely considers whether reports of an unusual disease event might be associated with deliberate or accidental release of a biological agent. A detailed standardised report on suspected and verified outbreaks is distributed electronically at the end of the day to a limited number of WHO staff at headquarters and in regional offices.

Despite some geographical and linguistic gaps (GPHIN currently scans sources in English and French only), the combined system for detection and verification is reasonably powerful and efficient. From July 1998 to August 2001, WHO verified 578 outbreaks, of which 56% were initially picked up by GPHIN (figure 3). These outbreaks occurred in 132 countries, indicating the system's broad geographical coverage. 22 countries, many affected by continuing conflict, had ten or more verified outbreaks of potential international importance. The most frequently reported outbreaks were of cholera, meningitis, haemorrhagic fevers, anthrax, and viral encephalitis.

Real-time alerts

To keep key members of the international community informed of the evolving outbreak situation, the WHO team distributes, on a weekly basis, an electronic Outbreak Verification List to over 800 individuals within the 110 networks and including staff in the national quarantine offices of WHO member countries. The list provides restricted access to news of both initial, unconfirmed, and potentially sensitive reports of outbreaks and the status of confirmed outbreaks undergoing investigation It is the primary method by which WHO alerts public health professionals around the world to potentially important outbreaks. Included in the list are details about the syndrome or disease, the location of the event, the source of the report, the number of cases and deaths, the status of investigation and identification of the causative agent, media coverage, and the contact details for WHO professional staff monitoring the event. The procedure aims to provide a

rapid yet reasonably authoritative early alert and thus facilitate preparedness to act, while also giving a large number of professional partners an opportunity to contribute additional information.

Once an outbreak has been verified, WHO posts situation reports on its web site and publishes them in the *Weekly Epidemiological Record*, which is available electronically, in English and French, and distributed in printed form to a large number of recipients in the developing world. By issuing authoritative public statements about the status of an outbreak and the need for any restrictions on travel and trade, WHO also helps guard against unnecessary reactions that could cause undue panic or interference with travel and trade. For example, when the media began reporting, in the first week of October 2001, that the largest ever outbreak of Crimean-Congo haemorrhagic fever had been detected along Pakistan's border with Afghanistan, WHO used background data about the endemicity of this disease to calm fears of an unusual epidemic. A WHO epidemiologist in the Pakistan country office investigated the situation within 24 h, the facts were immediately reported on the WHO web site, and several news organisations corrected their stories.

Rapid response

When risk assessment determines that an international response is needed to contain an outbreak, it draws on its partners in the Global Network. Specific support provided includes on-the-spot investigations, confirmation of diagnosis, handling of dangerous (biosafety level III and IV) pathogens, case detection, patient management, containment, and provision of logistics in the form of staff and supplies. In addition, WHO's six regional offices and 141 country offices in less-developed countries provide an important geographical resource for coordinating containment operations within countries and their neighbours. Although the size of these offices varies according to the disease situation in the country concerned, all offices are staffed with medical experts and often with epidemiologists, and all have the essential logistic equipment, including vehicles and local communications, needed for prompt on-the-scene investigation of a suspected outbreak. Investigative teams from WHO Headquarters in Geneva are prepared to arrive at an outbreak site within 24 h. Since early 2000, WHO and the Network have launched effective international responses to naturally occurring outbreaks in Afghanistan, Bangladesh, Côte d'Ivoire, Egypt, Ethiopia, Kosovo, Saudi Arabia, Sierra Leone, Sudan, Uganda, and Yemen (figure 4).

The framework for response: a three-pronged approach

The framework for responding to outbreaks and epidemics relies on a three-pronged approach, with different strategies for combating known risks and unexpected events, and for improving both global and national preparedness.

Containing known risks

Epidemic-prone diseases, such as cholera, dengue, influenza, measles, meningitis, shigellosis, and yellow fever, and foodborne diseases pose a constant threat to human populations. They are well adapted to transmission in human populations either directly from person to person, through transmission by insects and other disease vectors, or by

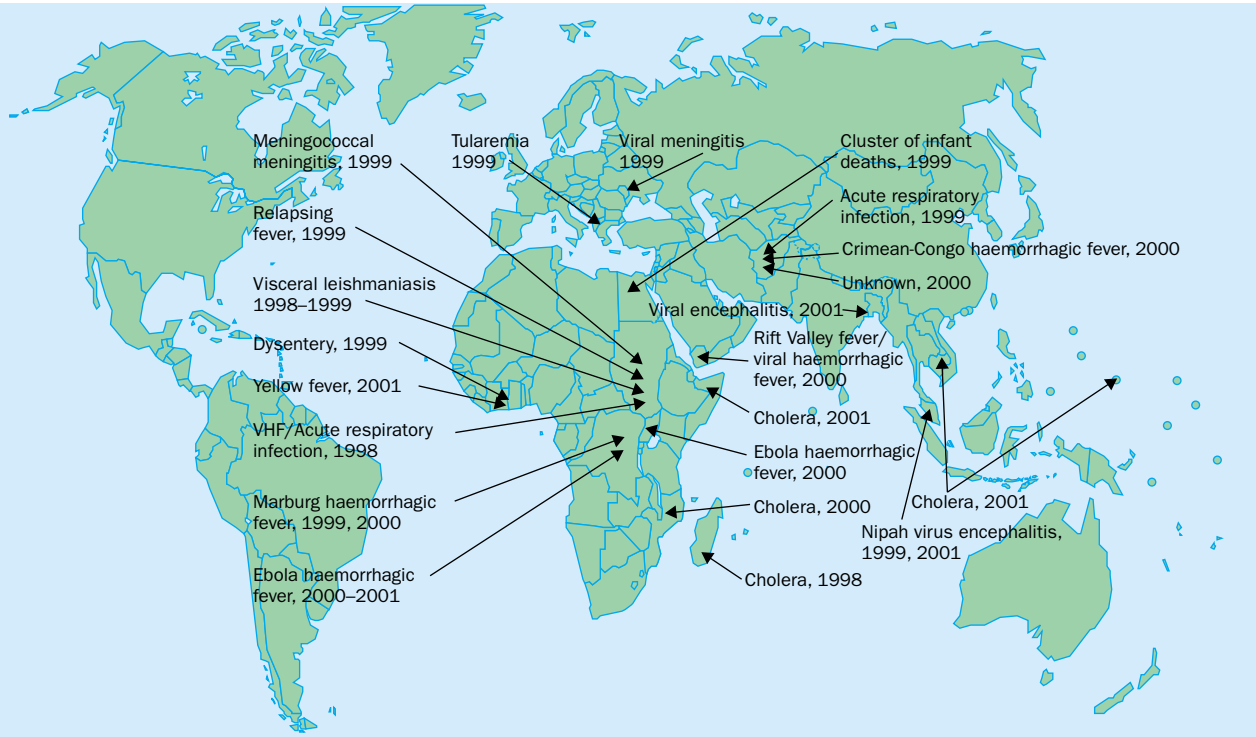

Figure 4. Some WHO-facilitated epidemic response missions in the field, 1998–2001. WHO has coordinated several large international responses to potentially explosive outbreaks. A WHO team is prepared to arrive at an outbreak site within 24 h. Source: WHO, 2001.

contamination of the environment or food. These diseases are generally well understood and, in most cases, effective measures are available for their control.

WHO maintains numerous programmes for the monitoring and control of these well-known and almost constant risks to public health. For monitoring, WHO coordinates several electronic "detective" systems and databases that interlink experts and laboratories around the world. These networks, most of which now operate in real time, keep watch over disease-related events ranging from new strains of influenza virus, through outbreaks of salmonellosis and dengue, to the emergence of drug-resistant pathogens. Most of these networks also include quality assurance and training components to ensure that data submitted from different parts of the world are comparable and conform to established standards. The oldest of these, FluNet, was established over 50 years ago and has served as the prototype for the design and implementation of subsequent systems.[36] The network, which now draws support from 110 collaborating laboratories in 84 countries, monitors newly emerging strains and subtypes of influenza virus and uses this information to determine the antigenic makeup of each year's influenza vaccines. The sensitivity of FluNet proved vital in providing an early alert to the first human cases of influenza virus A (H5N1) in Hong Kong in 1997, where early detection, followed by an investigation to determine and eliminate the source, helped avert a more widespread epidemic.[37]

When outbreaks occur, disease-specific networks of partners help WHO mount a rapid response, while standardised protocols for containment, based on widespread experience, facilitate prompt, coordinated action. For some of these infections, such as epidemic meningitis, influenza, and yellow fever, WHO also collaborates with researchers and industry to anticipate future outbreaks and ensure that adequate emergency vaccine supplies are available when needed. Such procedures proved instrumental in the quick detection and containment, through mass vaccination, of the potentially explosive outbreak of urban yellow fever in Côte d'Ivoire in September 2001.

Responding to the unexpected

Unexpected or unusual disease events can be caused by previously unknown infectious agents, agents that have crossed the species barrier from animals to people, agents appearing in a new geographical area, and potential agents that could have been deliberately engineered and introduced by acts of bioterrorism. Novel pathogens are often poorly understood in terms of their source and mechanisms of transmission, and many have the potential to cause large outbreaks. Fortunately, some of these pathogens are not well adapted to human populations and lack the potential for sustained, epidemic spread. As experiences with the AIDS epidemic have demonstrated, however, sustained epidemic spread is a distinct possibility that can have a major impact on societies and economies as well as on the life expectancies of countries. Whereas novel pathogens may not always cause major outbreaks, they are often associated with high death rates, since they are poorly understood as they emerge, and initial prevention or treatment strategies are absent or ineffective. Examples include hantavirus infections, Ebola and, most recently, Nipah virus.

The work of coordinating large-scale international responses to the unexpected (the Ebola outbreak in Uganda in October 2000 drew 120 professional staff from 22 partners in the Global Network) is facilitated by WHO operational protocols, which set out standardised procedures for the alert and verification process, communications, coordination of the response, emergency evacuation, research, and relations with the media. WHO has also revised its guidelines for the behaviour of foreign nationals during and after field operations in the host country. By setting out a chain of command and executing the containment response in an orderly way, these protocols help protect against the very real risk that samples of a lethal pathogen might be collected—during the often hectic conditions that surround an outbreak—and then be used in a harmful way.

Improving preparedness

WHO conducts a number of activities aimed at helping countries strengthen their laboratory and epidemiological capacity and take advantage of new tools, such as HealthMap (an interactive information and mapping system) and remote sensing data from satellites, that can help recognise environmental and meteorological conditions favourable for an outbreak. In collaboration with the CDC, WHO facilitated formation of the Training Programmes in Epidemiology and Public Health Interventions Network (TEPHINET), a global network linked to the Global Outbreak Alert and Response Network, which seeks, through shared resources and expertise, to enhance the effectiveness of national training programmes in epidemiology.[38] In February 2001, WHO opened a new office in Lyon, France, to provide 2-year specialised training for epidemiologists and laboratory specialists from developing countries where the epidemic risk is greatest. The training, which includes a 6-week course in Lyon, is followed by specially tailored field work and support in the home country, supervised by Lyon-based staff. In so doing, the new programme is working to strengthen disease detection and response activities in those countries where epidemics and unexpected disease events are most likely to occur.

Disease reporting in a wired world

Traditionally, one of the main factors undermining the effectiveness of infectious disease surveillance has been the reluctance of countries to report outbreaks due to fear of the negative impact this news would have on travel, trade, and tourism.[39] Outbreaks are always costly, and most especially so when reactions are inflamed by sensational media coverage. Widespread and sometimes exaggerated media coverage of the 1994 plague epidemic in India contributed to trade and tourism losses in the range of US$2 billion.[40] Public alarm over the safety of beef, sparked by the epidemic of bovine spongiform encephalopathy, prompted the European Union to introduce a series of control measures that will cost an estimated US$2·8 billion in 2001 alone.[41] With such costs on record, countries with fragile economies are understandably reluctant to admit the occurrence of outbreaks that are almost certain to result in severe economic losses.

On the positive side, new forces at work in an electronically interconnected world are beginning to break down this traditional reluctance for disease reporting. In line with the growth of electronic media, about 65% of the world's first news about infectious disease events during the past 4 years has come not from official country notifications but from informal sources, including press reports and the internet, of the kind now routinely picked up by GPHIN. Transparency about outbreaks and prompt reporting have therefore become increasingly important. Unverified rumours of an outbreak or unusual disease can have a negative impact on travel and trade in the country and its neighbours, even though the rumour may be totally unjustified or grossly exaggerated.

In the new order of the electronic era, countries are increasingly aware of the advantages of prompt outbreak reporting and official verification, accompanied by prompt international aid when needed, and prompt advice from WHO to the international community about the associated risks and the realistic need for restrictions on travel and trade. For example, during the Ebola outbreak in Uganda, WHO was informed as soon as the first suspected cases were detected, and a WHO-coordinated investigative team was on the spot within 24 h. Throughout the 5-month-long epidemic, WHO issued 42 updated reports on the epidemic via its web site. The country's borders were never closed.[42]

WHO's ability to act quickly, wherever an outbreak might occur and from whatever source, takes its legitimacy from provisions in the International Health Regulations, which set out the international framework to detect and prevent the spread of infectious diseases.[43] The current regulations, in force since 1971, have a number of weaknesses, which led WHO to initiate a major revision in 1995. Under present provisions, WHO member states are required to report only three diseases considered to be of international importance: plague, cholera, and yellow fever —clearly an inadequate defence against the dynamics of the current epidemiological situation, which includes many other diseases with great potential for international spread. Moreover, WHO is expected to postpone its response to suspected outbreaks pending receipt of an official government notification.

In response to these weaknesses, the regulations are currently undergoing substantial revision to bring them in line with the demands of a disease situation made vastly more volatile by the globalisation of travel and trade, the spread of antimicrobial resistance, and the accelerated emergence of new disease threats. Important revisions, currently nearing completion, include a considerable broadening of scope to embrace all infectious diseases of international importance, especially new and re-emerging diseases, and establishment of a clear mechanism for confidential collaboration between the affected country and WHO. Perhaps most importantly, the revised regulations are being developed to better protect countries from the consequences of unofficial reports.

In May 2001, the World Health Assembly adopted by consensus a resolution on global health security that endorses the direction of these revisions and considerably strengthens WHO's capacity to support countries in response to outbreaks and epidemics.[44] WHO is now in a position to use information on suspected outbreaks and epidemics other than that officially communicated by governments. Though WHO continues to confer, in confidence, with governments and secure their agreement to mount an international response, this strengthened capacity allows WHO to interact with countries with unprecedented speed.

Search strategy and selection criteria

We primarily cite articles containing global infectious disease surveillance data verified by WHO (Weekly epidemiological record; technical report series; World Health Assembly documentation). The WHO outbreak alert and response database was also scrutinised for material. Medline searches were carried out for each infectious disease referred to in the text.

Preparedness for the unthinkable

As public health authorities have long been aware, the many behind-the-scenes efforts needed to safeguard public health often go unnoticed and are inadequately funded—until something dramatic goes wrong. High-profile events such as an outbreak of foodborne disease, contamination of the water supply, or dangerously high levels of environmental pollution that arouse deep popular concern can suddenly bring into focus the need to strengthen the otherwise invisible infrastructures that protect public health on a daily basis. After the terrorist attacks on New York City and Washington, DC, questions about the deliberate use of biological or chemical weapons, and the preparedness of the world to respond, have been raised with great urgency. The message from WHO and its many partners in the Global Outbreak Alert and Response Network is that the infrastructure for detecting a bioterrorist attack and responding is firmly in place. The epidemiological and laboratory techniques needed to detect, investigate, and contain a deliberate outbreak are the same as those used for natural outbreaks. The existence of a routine, sensitive, and near real-time disease surveillance system enhances preparedness for deliberate as well as natural outbreaks. Moreover, adequate data on the prevalence of natural background diseases, such as that collected and used by WHO in outbreak verification, aid recognition of an unusual and possibly deliberately caused disease.

When asked if WHO is concerned by the prospect that biological agents might be deliberately used, the answer is straightforward. The world faces the prospect of surprises arising from the volatile microbial world on a daily basis. Aided by powerful new mechanisms and tools, WHO and its partners are permanently concerned, permanently on the alert, and permanently ready to act. The multiple threats posed by infectious diseases—whether well known or unexpected—have global causes and consequences that can only be addressed through global solutions supported by strong national capacity. If the present drive to improve global health security results in the strengthening of national capacities to detect and respond to infectious diseases, the entire global community will benefit.

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World Health Organisation: www.who.int/
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Weekly Epidemiological Record: www.who.int/wer/
Infectious diseases: www.who.int/health-topics/idindex.htm
Communicable disease surveillance and response: www.who.int/emc/index.html
WHO training office in Lyon, France: www.who.int/emc/lyon/index.html
HealthMap: www.who.int/emc/healthmap/healthmap.html