WORLD HEALTH ORGANIZATION

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Strengthening pandemic-influenza preparedness and response

Strengthening health and surveillance systems: use of information technology and geographical information systems

Report by the Secretariat

1. Geographical information systems grew out of sophisticated satellite imaging technologies originally developed for military applications. Today, the systems use maps generated by civilian satellites that remotely sense features of the earth and its atmosphere, such as topography, vegetation, and precipitation zones, and locate these features in space, using a system of latitudinal and longitudinal coordinates.

2. This mapping function is supported by the processing power of computers, whereby multiple layers of additional data, selected as relevant to a particular problem in a geographical area, can be superimposed on maps. Information from multiple sources is transformed into a common format that allows the user to visualize the spatial relationships and interactions of different determining factors, thus facilitating analysis and interpretation. Such technologies are particularly well suited to problems – including many diseases and other health conditions – that have multiple determinants, some of which are influenced by environmental or geographical factors. These features have made the technologies useful managerial tools for activities ranging from the search for natural resources to urban design, environmental engineering, and agricultural planning. This broad utility has, in turn, led to continual improvements in hardware and software, a considerable lowering of prices, and the expansion of high-quality databases.

3. Use is also made of the Global Positioning System, for satellite-based navigation. Inexpensive hand-held devices are now available to receive radio signals, determine the user's exact location, navigate movement, and calculate the distance to destinations and the time needed to reach them. Public health is now benefiting from these developments, which have made sophisticated information technologies applicable under remote field conditions, at prices affordable in developing countries, and with a simplicity that allows their use after a five-day training course.

PUBLIC HEALTH APPLICATIONS

4. The use of geographical information systems for public health purposes began in 1993 in response to operational needs of dracunculiasis eradication. WHO developed a user-friendly computer application, the HealthMapper, which used data from geographical information systems to identify

precisely the remote rural areas where geographical conditions favoured disease transmission. HealthMapper allowed the visualization of disease foci, the monitoring of newly infected or reinfected villages, and the highly targeted, cost-effective distribution of interventions. In so doing, it quickly provided dynamic, purpose-driven data that would otherwise have become available only after time-consuming, costly and static field research requiring constant repetition.

5. This pioneering achievement also had broader results. It demonstrated how new information technologies could be used to gather essential data in ways that saved time and reduced costs; it showed how unique data collected at village level for one health programme could be immediately used by others; and it created a demand for customized mapping technologies suited to the needs of other major disease eradication and elimination initiatives.

6. HealthMapper has since been further simplified, enhanced, adapted to meet multiple public health needs, and made compatible with other public health information platforms, including the epidemiological software tool Epi Info. Recent versions readily incorporate remotely sensed satellite data and data from the Global Positioning System. In addition, it now packages core baseline data on geography, demography, and key features of health, education, and transport systems and of the agricultural and water supply and sanitation sectors for a large number of developing countries.

7. Many public health applications derive from the close links between the behaviour of infectious diseases and environmental factors, including temperature, elevation, soil conditions, land use, rainfall, and other meteorological conditions. For public health purposes, satellite-generated maps can be combined with spatial data on physical features, such as the location of health facilities, schools, roads, farms, rainforests, and water bodies, or data from other sources, such as information on population density, patterns of land use, seasonal precipitation, and the ecological behaviour of insect and animal vectors of disease. Such applications facilitate the planning and implementation of measures for disease prevention and control. For example, patterns of vegetation can be remotely sensed by satellite and mapped; when this information is juxtaposed with data on the habitats of vectors, meaningful conclusions can be reached about the location of populations at risk of vector-borne diseases. Or, if a district-level map of schools is superimposed on a map of water distribution, schools with children at the highest risk of schistosomiasis infection can be rapidly identified, thus dramatically reducing the number of children who need to be surveyed and tested for the disease.

8. Geographical information systems and mapping technologies are now directly linked to WHO's event management system for public health emergencies of international concern. This electronically managed tool guides decisions pertaining to outbreak alert and response by grouping information from early warning systems, risk assessment and the operational response. As an example of this link, conditions related to geography that have been associated with past outbreaks can be superimposed on maps to generate a picture of areas at greatest risk, and the time of the year when the risk is expected to peak. Moreover, because satellite-generated maps and their associated data are transnational in nature, they can help to identify factors that favour the spread of an infectious disease from one locality to neighbouring countries. In so doing, they can also supplement national surveillance systems in detection of diseases with a potential to spread internationally.

9. Use of these technologies and standardized methods of data collection and display makes it possible to generate a complete picture of a disease situation, from global to community levels. In particular, applications at district level are helping to find solutions to long-standing problems in ways that make the best use of scarce resources. In recent years, WHO has used mapping technologies to locate service provision in relation to prevalence of disease with a precision that allows decisions to be made about the adequacy of local health facilities, the number of staff, the caseload they face, and the

medicines and other supplies most urgently needed. The technologies have also been used to create inventories and maps showing which partner agencies are working in a particular area and the services they are providing, thus allowing identification of gaps and overlaps.

10. Mapping technologies are also employed to improve use of data collected at district level, and their incorporation in the national surveillance system for early warning purposes. HealthMapper assembles existing data from multiple sources, such as epidemiological surveys, laboratories, hospital records, and nongovernmental organizations, and displays them in meaningful ways related directly to disease prevalence and health system capacity. Further, new information technologies make it possible to transfer data from rapid epidemiological assessments, entered in a hand-held personal digital assistant, to a computer, then to upload the data into a mapping system for immediate field analysis and transfer to national or global information networks.

11. The HealthMapper currently provides support to a range of infectious-disease activities in more than 100 countries in all WHO regions. Well-developed applications include the rapid and precise identification of populations at risk of endemic infectious diseases, and the targeting of interventions. For example, the technology facilitates operation of large eradication and elimination campaigns in ways ranging from the identification of populations needing treatment for lymphatic filariasis, to the monitoring of ivermectin distribution for onchocerciasis, to global surveillance of remaining pockets of poliomyelitis, dracunculiasis, and leprosy. In malaria control programmes, these technologies are being used to monitor the number of children who sleep under insecticide-treated nets and to identify areas where the use of nets has successfully lowered incidence of infection. For HIV/AIDS, mapping prevalence in risk groups, together with data on service facilities, allows planners to determine immediately where prevention and treatment activities can be intensified.

12. Health mapping technologies are now a core component of WHO activities to improve outbreak awareness, preparedness, and response. They routinely provide support to the daily activities of WHO's Strategic Health Operations Centre, which serves as a hub for gathering and interpreting disease intelligence, and coordinating international responses to public-health emergencies. These technologies are especially well-suited to the dynamic nature of outbreaks and have significantly advanced the ability to track and visualize outbreak evolution in real time.

13. New information technologies also contribute in specific ways to the ground response to outbreaks. Baseline data packaged in HealthMapper help to determine when the response effort needs to compensate for absence of local transport, inadequate communications equipment, or rudimentary infrastructure. Baseline data further guide transportation of teams and supplies by the fastest means, and show where supportive health infrastructures are located. Use of the Global Positioning System locates and maps disease foci and navigates the movement of response teams.

APPLICATIONS RELATED TO AVIAN INFLUENZA AND PANDEMIC INFLUENZA

14. Like many other infectious diseases, highly pathogenic H5N1 avian influenza is influenced by many environmental factors. Experience over the past two years has revealed seasonal peaks in animal outbreaks and associated human cases. Survival of the virus in the environment is influenced by conditions of temperature and humidity. Risk factors for human infection are now better understood, and are known to be associated with human proximity to poultry in rural and periurban areas. Most recently, migratory birds have been implicated in spread of the virus to new areas. Technologies can be used immediately, for example, to map outbreaks of avian influenza and poultry densities in affected countries in order to identify human populations at risk, determine their access to health care,

and pinpoint areas where surveillance should be intensified. The mapping of wetlands and the flight routes of migratory birds can identify countries at risk of importation of the virus and indicate times of the year when veterinary surveillance, possibly with international assistance, should increase. HealthMapper can make such maps meaningful for health planners by plotting population densities and showing health service capacity in areas at risk, particularly in Africa.

15. Baseline health and demographic data, already collected for a large number of countries, can provide the foundation for rapidly adapting health systems to cope with a pandemic emergency. HealthMapper can be used to identify schools and other facilities that could be converted to handle abrupt surges in the number of people seeking health care. Logistic arrangements during a pandemic can likewise be expedited. HealthMapper’s ability to guide the delivery of population-wide interventions has direct applicability during a pandemic. Mapping technologies can help to predict, in real time, the spread of a pandemic globally, within a country, or within a community.

ROUTINE APPLICATION IN COUNTRIES

16. To date, the public health benefits of geographical information systems and mapping technologies have been used mostly during large health campaigns and international responses to public-health emergencies, including those caused by outbreaks and natural disasters. The challenge now is to extend these benefits more widely to health systems in developing countries so that these powerful technologies become an integral part of routine surveillance and planning, particularly at district level. WHO’s relevant programme of work is being pursued in collaboration with a large number of international partners.

17. National capacity to make better use of these technologies would be most rapidly enhanced if three main activities were undertaken. First, better international coordination is needed to define standards and protocols that allow the exchange of comparable data among the many agencies and institutions currently using geographical information systems and mapping technologies for public health purposes. Second, major gaps in essential baseline data need to be filled, particularly for rural areas which may not be reached by conventional surveillance systems. Lastly, mapping technologies need to be further enhanced to allow their full integration into high-speed national and international surveillance systems, which form the backbone of early warning and alert systems. These activities could result in the rapid and permanent strengthening of surveillance and response capacities in ways that would also allow ready incorporation of further improvements in information technology. Such improvements could likewise be expected to make a fundamental contribution to the strengthening of health systems.

ACTION BY THE EXECUTIVE BOARD

18. The Executive Board is invited to note this report.

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