Isolation versus quarantine and alternative measures to control emerging infectious diseases

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ABSTRACT

In the past 25 years, the world has witnessed the emergence and re-emergence of many infectious diseases. In the early stages of their emergence, isolation and quarantine may be the only and last resort to effectively control infectious diseases when we are confronted with limited or no knowledge of a newly identified and previously unknown contagious disease, which causes a serious public health threat either locally or internationally. The article traces back the origins of isolation and quarantine; defines precisely the terms isolation and quarantine as they are currently used in the modern era; compare and contrast these terms; identifies some of the harmful consequences of applying quarantine measures; highlights considerations for the use of isolation and quarantine; and identifies alternative measures adopted by the world health community to respond to emerging and re-emerging health threats.

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As we begin the 21st century, the so-called emerging infections have received increasing attention from infectious disease experts, public health agencies and the general public. Emerging infections generally refers to infectious conditions that are increasing in terms of their extent or impact on the population, although the term can also describe microorganisms that are appearing for the first time.[1] The World Health Organization (WHO) defines the term emerging infectious diseases as the "result from newly identified and previously unknown infections, which cause public health problems either locally or internationally".[2]

Although many believe that infectious diseases have no longer loom as a major risks to the public at least in the industrialized world, data from WHO indicate that they remain the leading cause of death worldwide.[3] The Centers for Disease Control and Prevention (CDC) shares this view: "Infectious diseases remain the leading cause of death worldwide. .... Unfortunately, historical success in treating and controlling some of these diseases left many health policy makers with the false perceptions that the threat to public health from infectious agents had all but disappeared. The resulting public health complacency has been costly in both human and economic terms."[4]

During the past 25 years, new or newly recognized diseases are being reported at the rate of approximately one per year. Acquired immune deficiency syndrome (AIDS) emerged as an important infectious disease in the early 1980's and is now entrenched on a scale that threatens global security. Other emerging diseases, such as Ebola, hemorrhagic fever and new variant Creuzfeld-Jakob disease, illustrate the severe damage caused by lethal new agents that cannot currently be curbed by vaccines or drugs. In 1997 and 1999, when influenza previously confined to birds and swine suddenly appeared in humans, experts voiced fears

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of a pandemic on the scale of deadly Spanish Flu of 1918. Severe Acute Respiratory Syndrome (SARS) is a current example of emerging infectious disease and certainly falls into this category. Altogether, over 31 new infectious diseases have emerged over the past 25 years. Widespread media attention to these emerging pathogens has heightened public concern and caused increased demands on the public health system to detect and control their spread.

Several factors contribute to the emergence and re-emergence of infectious diseases, but most can be linked with the increasing number of people living and moving in the world; rapid and intense international travel; overcrowding in cities with poor sanitation; substantially increased international trade in food; mass production of food and unhygienic preparation practices; increased exposure of humans to disease vectors and reservoirs in nature; and alteration of the environment and climatic changes, which have a direct impact on the composition and size of the population of insect vectors and animal reservoirs. Other factors include a deteriorating public health infrastructure, which is unable to cope with the needs of the population. A more complete listing of factors responsible for emergent infections include factors drawn from social, behavioral, environmental, and health system categories.[5]

The economic cost of emerging and re-emerging can be enormous. In recent years, wealthy nations have been stunned by outbreaks of food-borne disease causing economic losses in the billions of dollars. Some experts place losses associated with the emergence of mad cow disease in Europe at close to $38 billion. In New York in the early 1990s, the emergence of multi-drug-resistant tuberculosis, with a death rate of up to 80%, incurred costs associated with the failure to prevent its spread estimated at over $1 billion. In the Russian Federation, the re-emergence of tuberculosis, including multi-drug-resistant forms, is estimated to have cost over $4 billion in 1999 alone (the treatment cost for multi-drug-resistant tuberculosis can be up to $3000 per person). Initial costs associated with cases of West Nile fever in New York have been placed at almost $100 million.[6]

Fortunately, the modern infectious disease arsenal has many weapons for the identification, prevention, treatment, and control of emerging diseases. Among the available weapons to identify infectious diseases in the community are reporting requirements (generally for health care providers and laboratories), surveillance efforts at the central and local levels, investigation of contacts of infected persons and diagnostic laboratory capabilities. Investigation of the source and extent of infectious diseases is another weapon with both disease identification and control capabilities. Weapons for controlling the spread of infectious diseases include monitoring of treatment to ensure compliance with treatment plans, immunizations and chemoprophylaxis for specific diseases and the use of isolation and quarantine, which were the only measures available for protection throughout most of human history. The authority for activities such isolation and quarantine derives from the police power of the governmental authority. In the early stages of an epidemic, isolation and quarantine may be the only and last resort to effectively control infectious diseases when we are confronted with limited or no knowledge of a newly identified and previously unknown contagious (transmitted person-to-person) disease, which cause a serious public health threat either locally or internationally.

This article attempts to address the following issues: a) trace back the origins of isolation and quarantine; b) define precisely the terms isolation and quarantine as they are currently used in the modern era; c) compare and contrast these terms; d) identify some of the harmful consequences of quarantines; e) highlights considerations for the use of isolation and quarantine; f) identify alternative measures adopted by the world health communities to respond on emerging and re-emerging health threats.

An evolving historical perspective. Throughout the history, public health and medical personnel have contended with epidemics and, in the process, evolved procedures to lessen morbidity and mortality. International health activities started with the imposition of quarantine and isolation on ships and sea-borne travelers to protect cities from the introduction of plague and other infectious diseases, particularly from the East.[7] Way back in the thirteenth century, ports along the Adriatic Sea introduced a period of isolation for ships including the passengers and goods as a protection against the importation of plague. A period of 40 days or "quarantenaria" became established later as the usual period of isolation for sea-borne travelers and goods suspected of harboring infectious disease. Therefore, the term "quarantine" was originally derived from the 40 days of offshore wait during which incoming vessels could not discharge passengers or cargo in the era when plague and other great epidemics swept across Europe.

The first quarantine legislation was enacted by the City of Venice in 1377.[8] By 1448, the Venetian authorities had established a complete code of quarantine regulations.[9] A large number of states followed the Venetian example. By the 1800's, the practices of isolation and quarantine had become common in the American colonies.[7] The fact that the causes of infectious diseases were not known at that time did not help to stop the enactment and enforcement of quarantine regulations. These

regulations remained more or less intact until the second half of the 19th century when the causes of major diseases were discovered and their epidemiology was clarified.[9]

In modern era, the only international law pertaining to the containment of infectious disease is the International Health Regulations (IHR). The IHR were promulgated by WHO under Article 21 of its Constitution in 1951 and, according to the WHO constitute the "only international health agreement on communicable diseases that is binding on member states".[8] Because quarantine measures were regarded as detrimental to the interests of international commerce, the purpose of the IHR is to ensure the maximum security against the international spread of diseases with a minimum interference with world traffic and trade. To achieve this, the IHR, among other things set out the most restrictive health measures that a WHO member state may take to protect its territory against the diseases subject to the IHR. However, many WHO and public health experts acknowledges that the IHR have historically failed to achieve its stated purpose.[10] One of the leading reasons for the failure of the IHR is that the regulations only apply to small number of diseases. In fact, since the eradication of smallpox at the end of 1970s, the IHR have applied to only 3 infectious diseases, namely cholera, plague, and yellow fever. The IHR do not apply to new infectious diseases that have emerged, such as AIDS, or are now emerging, such as SARS.

At the national level, most governments have enacted public health statutes that authorize isolation and quarantine as measures to control infectious diseases. However, many of these statues are quite old and have not been widely used in recent years. Subsequently, the control measures, especially quarantine, became more rationalized and has somewhat faded in recent years. A review of the medical literature found no large scale human quarantine implemented during the 20th century.

In Japan, for instance, the government imposed isolation and quarantine on thousands of Hansen's disease patients, otherwise known as leprosy, since the beginning of the 20th century.[11] In 1900, the number of leprosy patients was estimated to be 30,000, and in 1919, the official number was 16,000. By 1950, the Japanese government estimated that there were 15,000 of whom 10,000 were confined in leprosaria. Until 1998, there were 15 leprosaria throughout Japan, of which 13 are national and 2 are private. These leprosaria housed and provide medical care to 4,300 residents who once suffered from Hansen's disease. In July 1998, 13 of these patients filed a lawsuit against the Japanese government alleging that the government, through its isolation policy, had infringed on leprosy patients' human rights as stipulated in the Japanese Constitution. The plaintiffs sought $1 million each in damages from the government. By the autumn of 2001, more than 2000 individuals had joined the litigation as plaintiffs. The 2,000 plaintiffs were not only residents of leprosaria, but also former patients who had been informally discharged by medical officers at leprosaria, as well as family members of deceased patients. On May 11, 2001, the Kumamoto District Court handed down a judgment ordering the government to apologize and to pay a total of $15 million in compensation to a first group of plaintiffs consisting of 127 leprosaria patients.[11] The verdict held the Japanese Ministry of Health and Welfare, which has been in charge of implementing public health policy towards Hansen's disease, responsible for failing to seek early reversal of the Leprosy Prevention Law. According to the court decision, the Japanese Ministry of Health and Welfare should have changed its quarantine policy in 1960 when the WHO issued a report denouncing the isolation of Hansen's disease patients, yet it failed to do so until the Leprosy Prevention Law was abolished in 1996. It also held the Diet (The Legislative Branch) responsible for its inaction on the issue ordering compensation and apology by the government as a whole. The court further declared that the isolation policy had violated Articles 13 and 22 of the Constitution pertaining to the dignity of the individual and freedom of movement, respectively. The judgment concluded that "since 1960, Hansen's disease has not been one that requires patients to be forced to live in isolation, and quarantine was therefore unnecessary after this time.".[11] On May 23, 2001, the Japanese Prime Minister announced his government's decision not to appeal the Kumamoto District Court ruling.[11]

In the United States of America (USA), no large-scale human quarantine has been imposed in the past 80 years.[12] However, authorities in some cases have quarantined large groups for several hours in response to bioterrorism hoaxes. United States of America authorities have recently invoked quarantines in anthrax hoaxes, even though anthrax is not contagious.

Despite the lack of modern operational experience of a large scale human quarantine, some countries commonly propose or have called for quarantine to manage outbreaks of some emerging or re-emerging infectious diseases. In the United States, for example, there was discussion of quarantining persons with AIDS when it became clear that AIDS was a communicable disease.[13] The resulting public outcry which was generated at that time never made public health authorities reluctant to use or discuss quarantine or isolation in another circumstances. The President of USA signed on April 4, 2003 an executive order adding SARS to the list of diseases for which infected individuals may be quarantined.[14] With placement of SARS on

this list, the disease becomes one of those conditions (including cholera, diphtheria, infectious tuberculosis, plague, smallpox, yellow fever and viral hemorrhagic fever) which health officials could exercise the legal powers vested in them to impose quarantine if circumstances warrant.

The Chinese government went further and have imposed a sweeping quarantine to control the SARS health crisis by sealing more than 2,000 health workers and patients inside the Beijing University People's Hospital complex.[15] Moreover, approximately 4,000 people who have intimate contact with others showing SARS symptoms were ordered to stay at home under quarantine. Communist party cells in work units and neighborhoods ferried food and other basic necessities to people confined to their homes, while monitoring them to ensure they do not flee. Isolation orders were also imposed on homes, factories, and schools where people who developed SARS symptoms, lived, worked or studied.

Historically, Kingdom of Saudi Arabia (KSA) has been free of quarantinable infectious diseases.[16] Infectious diseases in KSA can be classified into 2 varieties: first variety which include the 6 infantile and childhood diseases namely tuberculosis, diphtheria, tetanus, poliomyelitis, whooping cough and measles; and second variety which include some others important infectious diseases. The Saudi Ministry of Health (MOH) is charged with the responsibility for reducing morbidity and mortality of both varieties of infectious diseases. The first variety is controlled through the Comprehensive Expanded Immunization Program implemented through over 1,750 primary health care centers distributed throughout KSA. The Saudi government commitment to this program was reflected in 2 Royal Decrees issued in the years 1979 and 1983.[16] According to these decrees, birth certificates will not be issued unless immunization against the 6 childhood diseases has been accomplished. Those 2 decrees were followed by a third one in 1988, specifying the immunization of all children against hepatitis B.[16] After the success of the immunization program, 2 other diseases were added to the immunization scheme. These were rubella and mumps, increasing the number of diseases covered by the immunization program to a total of 9.

The second variety of infectious diseases are controlled through a surveillance system of cases and adaptation of quick, efficient, preventive procedures against imported infectious and epidemic diseases. Under such system, morbidity and mortality caused by infectious diseases in different health districts are registered, classified and tabulated. The MOH also undertakes analysis and adopts preventive procedures to halt the communication of diseases by those entering the KSA. These procedures include examination of employees arriving in KSA by conducting laboratory and x-ray tests and others, to ensure that they are free from infectious diseases, especially AIDS, as well as by preventing entrance to the country of those infected with disease.

In KSA, which is the home to some 6 million foreigners, quarantine centers also play an important role in the enforcement of quarantine policies and regulations which ensure protection from causative factors of infectious disease to KSA. The MOH prepares the health control programs for air, sea and land travelers entering KSA, and ensures that they are correctly implemented. This is accomplished through the issuing of lists and technical circulars concerning quarantine control to quarantine centers established on the 24 air, sea, and land routes which provide access to KSA and by providing them with manpower and other requirements. This ensures that individuals suspected of carrying infectious diseases are identified and isolated. It is also worth mentioning that the activities of the quarantine centers increase during the Hajj season, especially in the fields of immunization and preventive medicine. Special immunization campaigns are carried out every year at the air, sea and land routes centers against cerebrospinal fever. Vaccination against meningitis A and C infection has been routinely recommended by the Saudi Arabian Government for pilgrims to the Hajj and Umrah following an epidemic of group A meningococcal infection in 1987.

However, following an outbreak of serogroup W135 meningococcal disease amongst pilgrims and their contacts during the 2000 Hajj season, the Saudi Government now requires all travelers to the Hajj and Umrah to be immunized against meningitis W135, in addition to meningitis A. This means getting the quadrivalent meningococcal vaccine (ACWYVax) instead of the usual AC meningococcal vaccine. In former years, pilgrims with an A+C vaccination protection contracted a meningococcal meningitis because of lack of protection against the pathogen serogroup "W135". The quadrivalent vaccine protects against groups A, C, W135 and Y meningococcal disease. All travelers over 2 years of age, including those vaccinated against groups A and C within the last 3 years, must be vaccinated once with the quadrivalent vaccine at least 10 days before arrival in KSA. Proof of vaccination with this quadrivalent vaccine is now required before visas for Hajj/Umrah are issued.

The health surveillance system in KSA was tested in 2000 when an outbreak of Rift Valley Fever (RVF) struck the southwest region of the country. On September 10, 2000, the Saudi MOH and subsequently the MOH of Yemen began receiving reports from primary health care centers and hospitals in the far western Saudi-Yemeni border

region of unexplained hemorrhagic fever in humans and associated animal deaths and abortions.[17] An epidemiologic investigation was conducted by the Saudi MOH in collaboration with CDC and the National Institute of Virology in South Africa. On September 15, 2000, using serological tests such as enzyme-linked immunoassay (antigen detection and IgM), polymerase chain reaction (a molecular method for detecting the viral genome), virus isolation techniques, and immunohistochemistry, CDC confirmed the diagnosis of RVF in all 4 serum samples submitted from KSA. The significance of these results was that it confirmed the first ever outbreak of RVF in KSA, and the first ever outbreak outside the African continent. This soil-virgin epidemic in the Arabian Peninsula raised the threat of expansion into other parts of Asia and Europe.

The activities of the MOH, Ministry of Agriculture and the Ministry of Interior to contain the outbreak included an intensive mosquito-control program; restriction of movement of domestic animals; a comprehensive educational campaign to eliminate contact with sick animals and mosquitoes (including provision of free permethrin-impregnated bed nets); encouragement to seek early medical evaluation of persons with febrile illness; and information for health care providers on the clinical presentation and management of suspected cases. Animal, human and vector surveillance was strengthened throughout KSA, including establishment of central human and veterinary virology laboratories in the capital city and Jizan, respectively. Since livestock was identified as the primary carrier of this disease, a kingdom wide survey among domestic ungulates, primarily, sheep and goats was conducted to define the boundaries of veterinary vaccination program. Additionally, a Royal Directive was issued instructing that all infected animals to be slaughtered and properly destroyed and their owners be compensated. Kingdom of Saudi Arabia, the world's largest importer of live sheep, goats, and camels, has also imposed a temporary ban on both the movement of livestock in and out of Jizan and the import of livestock from several African countries as well as from Yemen. These measures proved successful in controlling the spread of RVF in a relatively short period of time.

During the peak of the SARS epidemic, the Saudi MOH barred all travelers who have visited any of the 5 SARS-stricken Asian countries (such as China, Singapore, Hong Kong, Taiwan, and Vietnam) from entering KSA as a precautionary measure to prevent SARS from reaching the country. All international airlines were notified not to transport any passenger coming to KSA from the SARS-hit countries via a third country unless that passenger has remained at least 10 days after departing from the last SARS stricken station. In addition, the MOH has used advanced equipment at international airports at Riyadh, Jeddah and Dammam capable of detecting suspected cases of SARS which were kept under observation for 10 days. Isolations wards were designated in major hospitals in all regions to admit suspected cases of SARS. The Saudi Foreign Ministry has also stopped issuing visas to Umrah pilgrims from China, Singapore, Hong Kong and Philippines. On July 9, 2003, KSA lifted the 3-month ban on SARS-hit countries. The Decision was based on the WHO's declaration that the SARS outbreak was contained worldwide.

Isolation versus quarantine. It is operationally important for public health officials and medical emergency mangers to use accurate terminology when dealing with isolation and quarantine measures. In the historical context, the terms isolation and quarantine were used interchangeably due to the fact that the causes of infectious diseases were not known. Therefore, isolation and quarantine were defined as the detention and enforced segregation of persons suspected to be carrying a contagious disease. This lack of clarity is reflected in the Oxford English Dictionary which defines quarantine as " a period of isolation imposed on a person, animal or thing that otherwise spread a contagious disease".[18] In modern era, however, we can clearly distinguish 2 separate strategy in the control of contagious diseases: quarantine and isolation.

The CDC, in its released first draft of a model law for the states (the Model State Emergency Health Powers Act) issued in October 2001, defines isolation as "the physical separation and confinement of an individual or groups of individuals who are infected or are reasonably believed to be infected with a contagious or possibly contagious disease from non-isolated individuals to prevent or limit the transmission of the disease to non-isolated individuals". In contrast, quarantine is defined as "the physical separation and confinement of an individual or groups of individuals, who are or may have been exposed to a contagious or possibly contagious disease, and who do not show signs or symptoms of a contagious disease, from non-quarantined individuals, to prevent or limit the transmission of the disease to non-quarantined individuals."[19]

Barbera et al use the term "large-scale quarantine" to differentiate it from incidents of exposure by only a few persons. They believe that it is most appropriate to use the term quarantine to refer to "compulsory physical separation, including restriction of movement, of populations or groups of healthy people who may have been potentially exposed to a contagious disease, or to efforts to segregate these persons within specified geographic areas."[11] On the other hand, they use the term

isolation to denote the "separation and confinement of individuals known or suspected (via signs, symptoms, or laboratory criteria) to be infected with a contagious disease to prevent them from transmitting disease to others."[11]

The Working Conference on Public Health Emergency Powers uses isolation as the term designating "extremely limited contact with an ill person who diagnosed with or suspected of having a communicable disease", and quarantine as the term designating "limited contact with an individual who may be in the incubation period of a disease.[20]

From the previous definitions, we can conclude that quarantine refers to the separation and restriction of movement of people who are not yet ill, but who have been exposed to an infectious agent and are therefore potentially infectious. Quarantine of exposed individuals is, therefore, a public health strategy and a police power function that is intended to stop the spread of infectious disease. Although quarantine measures may be instituted and forced for both individual persons and populations, the term is used more frequently to discuss measures undertaken at a population-wide level.

In contrast, isolation is a special case of quarantine and refers to the separation of people who have a specific infectious illness from healthy people and the restriction of their movement to stop the spread of that illness. In this sense, isolation is a standard medical procedure used in hospitals today for patients with tuberculosis and certain other infectious diseases. It is also used routinely for short, controlled periods of time for patients undergoing certain types of chemotherapy and organ transplantation. It may be reverse isolation, to protect the person being isolated. The most famous reverse isolation cases are children suffering from bubble boy disease who usually kept in the isolation chamber because they do not have a functioning immune system.

To assist hospitals in maintaining up-to-date isolation practices, the CDC has revised the "CDC Guideline for Isolation Precautions in Hospitals". The revised guideline contains 2 tiers of precautions. In the first tier are those "Standard Precautions" designed for the care of all patients in hospitals regardless of their diagnosis or presumed infection status. Standard Precautions are designed to reduce the risk of transmission of microorganisms from both recognized and unrecognized sources of infection in hospitals. They synthesize the major features of Universal (Blood and Body Fluid) Precautions (designed to reduce the risk of transmission of bloodborne pathogens) and Body Substance Isolation (designed to reduce the risk of transmission of pathogens from moist body substances). Standard Precautions apply to 1) blood; 2) all body fluids, secretions, and excretions, except sweat, regardless of whether or not they contain visible blood; 3) non-intact skin; and 4) mucous membranes. Implementation of these Standard Precautions is the primary strategy for successful nosocomial infection control.

In the second tier are "Transmission-Based Precautions" designed only for the care of specified patients. These additional precautions are used to interrupt transmission in hospitals for patients known or suspected to be infected or colonized with highly transmissible or epidemiologically important pathogens that can be transmitted by airborne or droplet transmission or by contact with dry skin or contaminated surfaces. These precautions may be combined for diseases that have multiple routes of transmission. When used either singularly or in combination, they are to be used in addition to "Standard Precautions". The revised guidelines also lists specific clinical syndromes or conditions in both adult and pediatric patients that are highly suspicious for infection and identifies appropriate Transmission-Based Precautions to use in empiric, temporary basis until a diagnosis can be made; these empiric, temporary precautions are also to be used in addition to Standard Precautions. For detailed description of the guideline recommendations for standard, transmission-based and empiric and temporary precautions, the reader is advised to visit the following website: (http://www.cdc.gov/ncidod/hip/isolat/isolat.htm).

Both isolation and quarantine may be conducted on a voluntary basis or compelled on a mandatory basis through legal authority. The medical, political and economic consequences of quarantine are sufficiently daunting to discourage it for further use in contemporary public health practices. The remaining of this article examines the harmful consequences of quarantines, key considerations in quarantine decisions and alternative measures to quarantines.

Harmful consequences of quarantines. Several harmful consequences can result from the uses of quarantines. The first and most important is the increased risk of transmission of infectious diseases in the quarantined population. The confinement of healthy people with infected people together greatly increased the risk of infection among the healthy people. This unfortunate consequence occurred in one of the most US controversial quarantines, which was imposed by the New York City Port authority in 1892 on ships traveling from Europe, where a cholera outbreak had originated.[21] Authorities sequestered passengers of lower socioeconomic status abroad arriving vessels below deck without sanitary provisions during the confinement. Consequently, cholera spread disproportionately among the poor on board the vessels and resulted in 58 deaths on one ship alone. The fact that quarantine prevents the spread of an infectious

disease to thousands or even millions of people has little comfort to those individuals who get the disease by being quarantined with others.

Another harmful consequences of quarantines is the possibility of civilian noncompliance that could compromise the quarantine and can lead to violence. For instance, when a quarantine was used to contain smallpox in Muncie, Indiana, in 1893, authorities had great difficulty convincing the citizenry that it was necessary.[22] Entire neighborhoods were quarantined by patrolling armed guards and many infected citizens were isolated under home detention and their presumably uninfected family members were quarantined with them. As a result, violence broke out and culminated in the shooting of several public officials. Public health officials ultimately concluded that their quarantine efforts had been a complete failure as the public had repeatedly resisted and defied their quarantine efforts.[22]

Quarantines may also result in unwarranted economic hardships to the quarantined geographic area and its inhabitants. A historical example of this possibility can be found in 1900 after the plague was diagnosed in several people in San Francisco, California.[23] In that year, the quarantine area boundaries were arbitrarily established in such a way that only Chinese neighborhoods of the city were included. This resulted in severe economic damage to the once-thriving Chinese business community. The issue was brought to the federal court which found that the quarantine unconstitutional on ground that it was unfair because public health authorities acted with a bad intention and unequal treatment.[23]

Considerations for uses of quarantines. Due to the harmful effects that may result from the use of quarantines to control the spread of infectious diseases, public health authorities must consider decisions to impose quarantine measures very carefully.

First, when considering using quarantine, public health authorities must weigh carefully whether the imposition of quarantine at the time of the discovery of a disease outbreak is medically warranted and has a reasonable scientific chance of substantially containing the spread of the disease. To reach a satisfactory resolution to this issue, public health authorities must analyze several aspects related to the disease in question including communicability, mode of transmission, incubation period, and available treatment. The essential first step in developing any disease containment strategy is to determine if the disease at issue is communicable. If not, no consideration of quarantine should be pursued. When considering mode of transmission, there is no valid public health or scientific justification for any type of quarantine measures in cases of disease outbreaks with low or no person-to-person transmission. Therefore, quarantines should only be considered when there is sufficient evidence that a disease is contagious and could pose a serious risk of wide-spread person-to-person transmission. The current SARS outbreak defiantly meets this standard since it has been established by public health experts that the causative agent, a previously unrecognized coronavirus, is spread by close contact between people.[24]

The next step of the analysis involves the incubation period. In the case of diseases with long incubation period (such as smallpox with incubation period ranging from 10-17 days) quarantine may not be an effective strategy to control the spread of infectious diseases. The long incubation period almost ensures that some persons who were infected will have traveled great distances from the site of exposure before the disease is recognized or quarantine measures could be implemented.

In addition to mode of transmission and incubation period, available treatment and prophylaxis options should also create the context for the decision process. Among the many diseases that are termed contagious (namely capable of being spread by contact with sick persons), only a limited number could pose a serious risk of widespread person-to-person transmission. Of these contagious diseases with potential for widespread person-to-person transmission, only a limited number confer sufficient risk of serious illness or death to justify consideration of imposing quarantine measures on large groups or geographic areas. And certainly, the availability of treatment and prophylaxis options to some of these contagious diseases makes the justification of the sequestration of large groups of people even less likely option. In the case of the SARS epidemic in which no treatment or vaccine available, the most effective way to limit transmission is to isolate those who have been infected and quarantine those who have been exposed. The underlying principle behind isolating infectious patients and quarantining those exposed is that the need of the many to be protected overweigh the needs of the individual to be free.

If the outcome of the previous analysis leads to a judgment that a quarantine would be an effective and necessary action to control the spread of a contagious disease outbreak, the next set of issues that should be considered involves the logistics or the necessary means to enforce it for as long as needed, which could be several weeks. The biggest problem with quarantine and isolation is the logistics of confining a large groups of individuals in one location. During previous events, the courts have required that those quarantined be detained in safe and hygienic locations and be provided with adequate food and other necessities.[25] Few health authorities or governments are able or want to pay for feeding, housing, and caring for patients placed

under isolation and quarantine. The public health nurse may not consider doing groceries shopping and laundry for quarantined individuals as a proper part of nursing duties. Hospitals do not like to take in infectious patients who require extensive isolation or quarantine procedures, especially when health care providers continue to be exposed to carriers of deadly diseases; the cost of these precautions is seldom reimbursed fully; and patients cannot be discharged until becoming noninfectious.[26] The shortage of trained medical personnel to adequately care for quarantines detainees should be anticipated and was clearly demonstrated during the influenza epidemic of 1918.[27] The behavioral reaction of law enforcement or military personnel charged with enforcing quarantine should also be considered. It is possible that fear of personal exposure or public reaction to enforcement actions may compromise police willingness to enforce compliance with quarantine requirements. Given these multiple demands for human and material resources, public health authorities must weigh the costs and benefits of devoting available resources to the maintenance of quarantine.

If valid public health and medical principles lead to a decision to impose quarantine, and it is established that a quarantine could be logistically practical and feasible, the possible unintended resulting harm must then be carefully examined. Questions to be answered in this stage include what are the health risks to those quarantined; what are the consequences if the public declines to obey quarantine orders; and what are the consequences of restricting commerce and transportation to and from quarantine areas; are the available logistics sufficient to carry out quarantine measures. These questions must be resolved by public health officials before the decision to impose a quarantine is taken. As noted previously, quarantines can increase the risk of disease transmission in the quarantined population. Previous quarantine events also illustrates that civilian unrest and economic hardships are possible outcomes of quarantines.

Alternatives measures to quarantines. In a world that is now closely interrelated in matters of health as well as in economics and trade, a quarantine may not be a feasible strategy to combat the threat of emerging diseases. Instead, defense against these threats requires a collaborative, multifaceted, global response. To encounter the threat posed by emerging or previously unknown diseases, the WHO has recently established innovative mechanisms which take full advantage of the powerful new opportunities for heightened vigilance and rapid response for disease outbreaks. The following are some of theses mechanisms adopted by the world health community:

Rapid response to disease outbreaks. In April 2000, the WHO formed the Global Outbreak Alert and Response Network. The network was designed to ensure the rapid response to disease outbreaks worldwide. It draws together 72 existing networks, many operating under WHO's responsibility, others maintained by national governments or regional non-governmental organizations. The networks reports and verifies information, on a daily basis, on a wide range of formal sources, including ministries of health, national institutes of public health, government and military health facilities and laboratories, and non-governmental organizations, such as the Red Cross. The work is facilitated by operational protocols, developed by WHO, which set out standardized procedures for the alert and verification process, communications, coordination of response, emergency evacuation, research, evaluation, monitoring, and relations with the media.

When a disease outbreak is judge to require international assistance, as agreed upon in confidential consultation with the affected country and with experts in the network, the WHO uses the latest electronic communication tools to coordinate quick and appropriate assistance. For example, during the Ebola outbreak in Uganda, WHO was informed as soon as the first suspected cases were detected, and WHO-coordinated investigative team was in the spot within 24 hours. 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. Since early 2000, the network has launched effective international responses in many countries including Afghanistan, Bangladesh, Egypt, Ethiopia, Kosovo, KSA, Leone, Sudan, and Yemen.

Semi-automatic electronic system. The system was developed for the WHO by Health Canada. It is designed to enable the WHO to scan the world for informal news that gives cause for suspecting an unusual disease event. The system continuously and systematically crawls Web sites, news wires, public health E-mail services, electronic discussion groups, including the US-based Pro-MED, and local online newspapers for rumors of outbreaks. Then, a WHO team responsible for outbreak verification investigates suspicious reports each morning to determine whether they pose a threat of international health concern. Whenever necessary, the WHO uses its technical and geographical capabilities to verify the presence of an outbreak. Since 1998, the WHO has used this system to verify over 800 outbreaks of potential international importance.

More proactive role for the WHO. 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 impacts this news would have on travel, trade, and tourism. However, this traditional reluctance is now beginning to change as a result of the growth of electronic media. During the past 4 years, approximately 65% of the world first news on infectious disease events have come from informal sources, including press reports and the internet.[6] In May 2001, the World Health Assembly, the supreme governing body of WHO, adopted by consensus a resolution on global health security that considerably strengthens the WHO's capacity to act in response to outbreaks and epidemics without prior official country notifications. Consequently, the WHO is now in position to investigate and verify rumored outbreaks even prior to receipt of an official notification from the government of the country concerned. This strengthens the WHO and allows it to act with unprecedented speed to disease outbreaks.

Strengthen national response capabilities. To improve global preparedness to combat emerging disease outbreaks, the WHO conducts a number of activities aimed at helping country strengthen their laboratories and epidemiological capacity and take advantage of new tools such as Health Map (an interactive information and mapping system), and remote sensing data from satellite systems. For instance, WHO supports the Training Programs in Epidemiology and Public Health Interventions Network (TEPHINET) which seeks, through shared resources and expertise, to enhance the effectiveness of national training programs.

Another approach to strengthen national response capabilities is to ensure that the energy and resources that are provided to a country for the investigation and containment of a disease outbreak are kept in that country for long-term technical assistance. During the Ebola outbreak in Uganda, containment activities left behind permanent improvements in the form of isolation wards at 2 hospitals in Gulu districts, a community-based early warning surveillance and response system for priority infectious diseases, and a community registry of births and deaths.[6] In June 2001, a new focus of 3 suspected cases of hemorrhagic fever was detected by local staff within 3 days of onset, patients were immediately isolated in the recently established ward, and specimens were dispatched for testing at the WHO Collaborating Center in South Africa, where results fortunately proved negative. In this case, strengthen national capacity made it possible to defend global health security through local vigilance, without the need for costly international assistance.

In conclusion, emerging diseases can be caused by previously unknown infections agents or pathogens that have crossed the species barrier from animals to humans. These novel pathogens are usually poorly understood in terms of their source and mechanisms of transmission, and many have the potential to cause large outbreaks and often associated with high death rates. As they emerge, an initial prevention or treatment strategies are either totally absent or ineffective. Examples include hantavirus, infections, Ebola, Nipah virus, and most recently, coronavirus. Throughout most of human history, isolation and quarantine have been used as the only measures available for protection against such emerging threats. In modern era, the meaning of the 2 terms have been clearly distinguished and their use, especially quarantine, has somewhat faded.

Several harmful consequences can result from the uses of quarantine, including increased risk of disease transmission in the quarantined population, the possibility of civilian noncompliance that could compromise the quarantine and can lead to violence and unwarranted economic hardships to the quarantined geographic area and its inhabitants. Due to such harmful effects, public health authorities must consider decisions to impose quarantine measures very carefully.

Fortunately, today's world is better equipped to protect itself, through preventive measures, than in the past, when isolation and quarantine comprised the sole measures for controlling emerging health threats. Aided by powerful electronic communication tools, key defense strategies now include rapid response to disease outbreaks, semi-automatic electronic system, more proactive role for the WHO and strengthen national response capabilities.

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