

HOW MUCH CONTROL OF COMMUNICABLE DISEASES?*

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The American Society of Tropical Medicine was established in Philadelphia, March 9, 1903 by a small group of well known clinicians who were members of the College of Physicians of Philadelphia. Of the 28 who signed the Charter, nine were members of the Jefferson Medical College Faculty. At the first public meeting, James Carroll, Surgeon, U. S. Army, addressed the Society on the subject "The etiology of yellow fever." Sixty-two years later, our Society can contemplate with pride the enormous contributions made during the past six decades in the field of tropical medicine by the membership of our current organization and its parent societies, particularly in the field of control of communicable diseases.

At the beginning of the twentieth century, communicable diseases were exacting a colossal toll of life in all areas of the world, but in the tropics and subtropics the losses were truly devastating. In the Tenth Edition of the Manual, "Control of Communicable Diseases" (American Public Health Association, 1965), Gordon contrasts the situation in 1915 when the First Edition listed control measures for the 38 communicable diseases then officially reportable in the United States, with the present volume which considers community management of 148 communicable diseases. The earliest edition dealt primarily with the control of *epidemics*, whereas today the primary effort is, "to recognize potential epidemic foci in their incipiency, and to identify areas of persistently excessive endemicity. Control activities today center around surveillance of disease."

The developed countries of the world have made tremendous strides in the control of typhoid fever, tuberculosis, diphtheria, smallpox, whooping cough, typhus, cholera, plague and many others. The developing countries still have major problems with many of these, as well as with certain others which are restricted to tropical and

subtropical areas. The virtual elimination of many of these epidemic diseases in the industrialized nations has given rise to serious consideration of global eradication of a few selected communicable diseases.

EVOLUTION OF THE CONCEPT OF ERADICATION OF COMMUNICABLE DISEASE

Eradication of a communicable disease is defined as the complete elimination of the infectious agent from the world. The term should be restricted to this concept and thus national or regional programs can only be considered in relation to the global effort. The financial implication in eradication is that a short term campaign will be much cheaper than the eternal maintenance of a control program. A limited time element is implied.

In 1909, John D. Rockefeller provided one million dollars to found the Rockefeller Sanitary Commission for the purpose of eradication of hookworm disease in the Southern United States.¹ The money was to be spent over a period of five years. Dr. Charles Wardell Stiles was the inspiration for this action. The program made dramatic progress, although it fell far short of its stated objectives. In 1913 the International Health Commission of the Rockefeller Foundation was established to extend these activities overseas. This later became the International Health Board, and in 1927 its name was changed to the International Health Division.

In 1915, the International Health Commission adopted a resolution indicating its willingness "to give aid in the eradication of yellow fever in those areas where the infection is endemic and where conditions would seem to invite cooperation for its control." This decision was based upon the success of Gorgas in clearing Havana of yellow fever and of his work in Panama. Soper, Wilson, Lima and Antunes describe the brilliant achievements of the anti-*Aedes aegypti* program in Brazil.² The nations of the Americas, acting through the Pan American Health Organization in 1947, determined to eradicate *Ae. aegypti* from the Western Hemisphere.

In 1916, Hoffman proposed the organization of

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a National Committee on the Study and Prevention of Malaria, to provide for effective governmental, state, municipal, corporate and general cooperation in finding methods and means aimed at the gradual eradication of malaria in every section of the United States where the disease was known to occur.³ The National Malaria Committee was active until 1941, when it became the National Malaria Society. In 1951 it joined with the American Society of Tropical Medicine to form our current Society. Hoffman had also succeeded in having a resolution adopted before the Second Pan American Congress, Washington, D. C., January 7, 1916, "that all American countries inaugurate a well considered plan of malaria eradication and control based upon the principle that the disease is preventable to a much greater degree than has thus far been achieved."⁴

Vector species eradication, in malaria programs, was undertaken successfully against *Anopheles gambiae* by the Brazilian Government and the International Health Division of the Rockefeller Foundation in 1939. Similar success against the same vector was achieved in Egypt in 1944-1945. While the National Malaria Eradication Program in the United States was not formally initiated until 1947, in 1944 Mountin proposed that it could be accomplished by a relatively small, concentrated effort directed at the foci where conditions were favorable for transmission.⁵ By November 1950, exciting progress was reported from Brazil, British Guiana, the United States and Venezuela on the subject of "Nation-wide Malaria Eradication projects in the Americas" at the National Malaria Society meeting.

The development of international health agencies provided the mechanism for joint undertakings such as global eradication. When the World Health Organization became operative in 1948, there was already in existence the Pan American Sanitary Bureau which had been organized in 1903, and this bureau became the Regional Office for the Americas of the World Health Organization. The topic of hemispheric eradication of malaria was considered at the 1950 Conference, and became a matter of agreement at the XVth Pan American Sanitary Conference in 1954 in Santiago, Chile. PASB was instructed to promote the intensification and coordination of antimalaria work with the objective of achieving malaria eradication in the Western Hemisphere. At the World Health Assembly in Mexico in 1955, it

was voted to give priority to global eradication of malaria, and the United Nations Children's Fund agreed to support it financially. Bilateral technical assistance became an integral part of the United States' foreign policy in 1942. By 1957, the United States Congress decided to initiate support of the global program. Private foundations, as indicated above, have played an important role.

Jenner announced his success in vaccination against smallpox in 1798. While the technique was promptly adopted and widely practiced, public health workers were apparently slow to grasp the possibilities of world-wide eradication. In 1853 England made vaccination compulsory, and in the decade 1911 to 1920 not a single death from smallpox was reported.⁶ The thirteenth Pan American Sanitary Conference in Santa Domingo, in 1950, recommended to its member nations that a program of vaccination and revaccination be implemented in their respective territories in an effort to eradicate the disease throughout the hemisphere. The Pan American Sanitary Bureau would serve as the coordinating agency.

In 1941, the Pan American Sanitary Bureau made a yaws survey at the request of the Haitian Government and developed plans for controlling the disease. Early in 1942 a limited control program, utilizing stationary clinics, was initiated by the Ministry of Health of Haiti and the Institute of Inter-American Affairs. The subsequent demonstration of the efficacy of a single injection of long-acting penicillin, and its cheapness and lack of toxicity, led to the establishment of a yaws eradication service in Haiti in 1950 by the Haitian Government, with technical aid from WHO and UNICEF. These latter international health agencies cooperated in a similar program in Indonesia in 1950.

CURRENT STATUS OF GLOBAL ERADICATION PROGRAMS

A very brief statement concerning four eradication programs follows, including mention of major problems associated with eradication and of the outlook for the future. Further details and appropriate references can be found elsewhere.⁷

Malaria. Just a decade ago, before global eradication of the disease was undertaken, it was estimated that there were more than a quarter of a billion persons who had clinical attacks of malaria annually, and that two and one half million died of the disease each year.⁸

It has been demonstrated that semiannual spraying of the interior walls and ceilings of habitations, and of the undersurfaces of larger pieces of furniture, with a formulation of 75 percent water-dispersible DDT to produce a residual film of 1 or 2 grams per square meter of treated surface results in the cessation of transmission of malaria after three or four successive years of spraying. This residual spraying procedure is designed to kill the particular female anophelines that are in search of human blood, and those that may have previously fed on a malaria carrier. The procedure rarely leads to the eradication of the vector. The second aspect of the attack is directed against the malaria parasite using antimalarial therapy. The chief difficulty is the location of the remaining individuals with malaria parasites in their blood. As the spraying program is continued, the rate of transmission of malaria is lowered markedly, relapses become fewer and fewer, and the usual blood survey techniques become unrewarding on a regional basis. The actual process of case-finding is designated as surveillance. This is implemented in two ways, active and passive surveillance. Active surveillance relies upon the assumption that the individual harboring malaria parasites in his blood in sufficient numbers to infect the anopheline vector will have fever and/or chills and that parasitemia can be demonstrated by blood smear. Surveillance workers are assigned to visit each habitation at least monthly, and to ask on each visit whether anyone in the house presently has fever or has had fever since the last visit, whether there are any visitors from outside the area who are sick, or whether there is any illness in the residents. If so, chloroquine suppressive treatment is administered to the affected individuals and blood smears are taken. Passive surveillance is maintained through the use of voluntary aides and notification posts. A blood film is taken if fever is believed to have occurred, and data on fever cases are obtained from all physicians, hospitals and laboratories. Each blood-positive patient is given the complete radical treatment, usually with primaquine. Furthermore, a thorough epidemiological investigation of each parasite-positive case is made, and if there is evidence of transmission, respraying of the locality is performed. This surveillance program is usually initiated in the third year of mass spraying but may be started earlier if the prevalence of malaria is low. This constitutes the *consolidation* phase of malaria eradication and is directed toward the

prevention of renewed transmission. It must be continued for a minimum of three consecutive years. This arbitrary time interval is related to the maximum period during which malaria relapses. At the end of consolidation all spraying will have ceased, routine surveillance may be discontinued and the *maintenance* phase is the continuing service of maintaining a watch against the possibility of reintroduction of malaria into the cleared area. This maintenance is a part of the routine activities of the Health Department, and a special staff is no longer required to keep the area free from malaria.

At the end of 1964, the status of malaria eradication in the various regions of the world was summarized in the WHO Chronicle (September, 1965). Of the estimated 1,560 million people in the originally malarious areas of the world from which information is available, 1,168 million (78%) live in areas where malaria has been eradicated or where eradication programs are in progress. Of these, 444 million are in maintenance-phase areas and 355 million are in consolidation-phase areas.

Johnson presented the status of malaria eradication in India from the point of view of a member of an international assessment team.⁹ Prior to World War II, it was estimated that in India at least 100 million people suffered illness and one million died annually from malaria. At an annual average cost of less than \$0.09 per person, the population of at least 450 million persons formerly at risk from malaria in 391 units was reduced by February 1965 to only 94 million, which were in areas still in the attack phase. Many of these are in areas which border on adjoining malarious countries. Thus, more than 350 million persons in India no longer require residual house spraying to protect them from malaria.

The dramatic progress of eradication in India is most reassuring. It promises that with proper administrative backing and financing, the goal of eradication may be achieved. The author is very conscious of such eventualities as the development of resistance by the malaria parasite to our best known antimalarials, and by the anopheline vectors to our better residual insecticides, and also the potential threat of simian malaria attacking man, yet he feels confident that global eradication is possible. The target date for its achievement in such areas as Borneo, New Guinea, Upper Amazon and Africa is not possible to estimate at the moment, but even a few decades

may be considered reasonable for these difficult areas when one considers the past deprivations of this plague.

Smallpox. Smallpox lends itself to large scale eradication if the campaign is adequately planned, financed and executed. Professional employees may be needed only for supervisory, administrative or consultative posts. The development of jet injectors will probably expedite the rate and reduce the cost of immunization in population centers. The logistics of bringing together the vaccine and scattered populations in remote areas and many illiterate groups has retarded progress in a number of endemic areas of the world.

The Western Hemisphere has been completely freed of the disease with the exception of Argentina, Brazil, Colombia and Peru. The Pan American Health Organization reported 2,502 cases from these four countries in 1964.

WHO reports the known occurrence of about 47,000 cases of smallpox in 1964. Most of these were in India (about two-thirds), but enormous progress has been achieved in the past few years in that country, where 280 million immunizations were performed between 1962-1964. About 35 percent still remain unvaccinated. The progress in Africa, south of the Sahara, has been much slower, and the reported cases of smallpox in 1964 probably represent very substantial under-reporting.

The estimated total cost of global eradication has been cited as \$100 million. Developed countries of the world cannot tolerate the continuing threat of smallpox to their peoples nor continue to expose certain segments of the adults to repeated vaccinations when the infection can be eradicated globally. It is estimated that currently the United States is spending more than \$20 million annually for the vaccination of 14 million individuals. Recently our government has pledged to assist in eradicating smallpox in the next decade.

Aedes aegypti eradication in the Western Hemisphere. The unfortunate occurrence of the yellow fever virus among certain simian and other hosts within the jungle, and its transfer among these reservoirs by jungle mosquitoes, often breeding in the canopy of the forest, had precluded the undertaking of a program for total eradication of yellow fever in the Western Hemisphere.

Progress to date in eradicating *Ae. aegypti* has

been successful in British Honduras, Bolivia, Brazil, Chile, Costa Rica, Ecuador, El Salvador, Guatemala, Honduras, Mexico, Nicaragua, Panama, Paraguay, Peru, Uruguay, and the Canal Zone. The situation in the Caribbean Islands is variable. Haiti, the Dominican Republic and Jamaica are not currently pursuing eradication programs. Many of the islands are believed to be negative, including Bermuda, Barbados, Grenada, St. Kitts, Nevis, Anguilla, St. Vincent, Trinidad, and Tobago. Other islands are known to be positive. Reinfestation was discovered in Colombia in 1963. British Guiana, French Guiana, and Surinam are infested. Cuba will probably not complete its program before the end of 1967. Resistance against DDT has been a major problem in the Caribbean. The United States began its five-year eradication campaign in the summer of 1964.

When the hemisphere completes its program of eradication of the urban vector of yellow fever, we will still be faced with foci of the jungle virus in a number of countries of South America. No large scale eradication program has yet been mounted in Africa.

One of the important fringe benefits of eradication of *Ae. aegypti* from the hemisphere will be the complete disappearance of dengue or break-bone fever. While this disease causes very little mortality, all of us who have experienced it can attest to its incapacitating, painful propensities. In 1963 more than 26,000 cases occurred in Puerto Rico.

Yaws. This truly tropical disease has been demonstrated to be highly susceptible to a single injection of a long-acting penicillin. Principally found among children in rural areas of tropical Africa, Asia, and the Americas, it was estimated that 50 million cases occurred in 1950. Half of these were in Africa. A warm, humid climate, scanty clothing, and the probability of close body contact of an uninfected person, especially a child, with a patient having infective lesions, facilitates its spread. Mass treatment campaigns are initiated in hyperendemic areas (over 10 percent positive); in mesoendemic areas (5-10 percent clinically active yaws in the community) there are programs of mass treatment of juveniles (all children before puberty and other obvious contacts); and in areas of low endemicity (under 5 percent) all household and other obvious contacts of infectious cases are treated with 1.2 million

units of procaine penicillin G in oil with aluminum monostearate (PAM) meeting minimum WHO requirements.

Following the initiation of the yaws eradication program in Haiti, expansion to Indonesia, Thailand and other areas of the world occurred rapidly. By the end of 1958 about 70 million had been examined for yaws in initial surveys assisted by WHO, and about 90 million had been examined in resurveys. Some 30 million active or latent cases or contacts had been treated with long-acting penicillin.

Enormous progress has been made in the Americas and in Asia. In Haiti only 15 confirmed cases of yaws were located in 1963 after a census of 1,680,000 persons, but unfortunately several hundred cases of infectious yaws were reported in 1964 (WHO information). No cases of yaws have occurred in Trinidad since 1961 nor in Tobago since 1959. In the Dominican Republic only 38 cases were diagnosed in 1963. It appears that yaws has been reduced greatly in the Americas, but that the "mopping up" phase requires the extra effort of a detailed administrative push and complete coverage and follow-up if true eradication is to be achieved. In Asia, yaws is definitely on the retreat. In 1960, in Indonesia and other Asian countries 42,000,000 persons were examined in campaigns against yaws undertaken with help from WHO and UNICEF.

The maintenance of the gains made in mass campaigns will be difficult in every instance, but particularly so where any diversion from the goal of eradication will be immediately reflected by reappearance of the disease.

CERTAIN CHILDHOOD DISEASES

Measles. Until just a few years ago it was accepted by the public at large that every child was destined to have measles (rubeola). Enders summarizes some aspects of this disease.¹⁰ In the United States from 1950 to 1959, he estimates there were 22 million cases of the disease, and that about 28,000 cases of measles encephalitis resulted. In the three year period 1956-1959 there were 1,471 deaths in the United States from measles. Mortality in India was 1,253, in Brazil, 58-67, per million. In Nigeria 5 percent of measles cases died, and in West Nigeria 15 to 25 percent of the cases admitted to the hospital died. In the West African Savannah belt 25 to 50 percent of measles cases proved fatal.

The Academy of Pediatrics Committee suggests that measles could be eliminated from the United States by 1970 if physicians and health personnel would take whatever steps are necessary to see that all susceptible children receive vaccine.

It must be recognized that the American public will not accept the current situation in which three or four million cases of the disease and several thousand cases of measles encephalitis occur annually. Assuming that the disease may be eradicated from our frontiers, we would then be faced with the problem of immunizing more than four million infants annually in the future. Until international efforts for global eradication are successful, we have no acceptable alternative but to achieve and maintain national immunity against this disease.

Poliomyelitis. Poliomyelitis attacked 38,476 individuals in the United States in 1954. Dramatic declines followed the introduction of the Salk killed vaccine and subsequently the Sabin oral attenuated vaccine. The ease of administration of the oral vaccine made possible a better acceptance than in other vaccines. In 1964 only 121 cases of poliomyelitis were reported in the United States, of which 94 were paralytic and 8 fatal. There is every reason to hope for eradication of this disease from developed countries. The small potential risk from Type III vaccine in adults remains to be evaluated, and to date this has discouraged the total mass immunization campaign within the United States. The potential for selecting poliomyelitis for a high priority, global eradication campaign is diminished by the fact that the more heavily populated countries of the world, chiefly in the tropics, do not recognize this disease as a prime public health problem. Gradually, evidence is accumulating that the incidence of paralytic disease is increasing in such areas. If a global program were to be undertaken, the developed nations of the world should be expected to provide the major financial and technical support of the campaign. Individual developing countries, where the disease does not strike terror into the hearts of its citizenry, cannot be expected to divert their limited professional and paramedical personnel and scarce financial resources from more pressing and obvious health programs.

Rubella. Rubella (German measles) had been considered to be a rather innocuous febrile disease until the rather disconcerting discovery that

maternal rubella during the first trimester of pregnancy leads to death of the fetus or the occurrence of congenital defects, such as congenital cataract, heart disease or deaf mutism in about 20 (10 to 30) percent of instances. Thrombocytopenic purpura and hepatosplenomegaly also occur. Unfortunately, rubella occurs more frequently in adult patients than does measles. About 18 percent of pregnant women have been demonstrated to have no evidence of immune bodies against this infection. Recently it has been demonstrated that the infant born from the pregnancy acquiring German measles during the first trimester often remains infected for 3 months or occasionally even a year, and then sheds the virus.

Weller and Neva have succeeded in developing a technique for the cultivation of the virus of German measles.¹¹ The difficulty of certain diagnosis and the frequent unavailability of positive information concerning the past occurrence of the disease in women of child-bearing age suggest that compulsory immunization of all female children should be contemplated as soon as efficient measures are developed. The public otherwise assumes the burden of the care of many defectives. Temporarily, the use of convalescent gamma globulin should be recommended for pregnant women who are known to have been exposed to infection and have a negative history of rubella. If success is achieved with development of prophylactic immunization (with either killed or attenuated virus vaccine) of female children, adolescents, and all women of child-bearing age, it might be logical to consider undertaking a national compulsory immunization program for a generation, with the hope that global eradication would evolve.

Diphtheria and pertussis. In 1928 there were 84,000 cases of diphtheria reported in the United States. In 1962 there were 444 cases. This indicates enormous progress, but unfortunately the toxoid merely offers protection against the toxin produced by the diphtheria organism, and its use will not lead to eradication of the diphtheria bacillus. It is not presently feasible to consider eradication of pertussis for a somewhat different reason, namely that we cannot use the present vaccine in adult populations.

OTHER VIRAL INFECTIONS (NON-VECTOR-BORNE)

There are large groups of respiratory and intestinal viral infections associated with much

disability. The common cold, influenza, and other acute respiratory diseases are well recognized not only for the disability produced directly by these infections, but also for debilitation of the victims and preparation for secondary invaders in the form of staphylococci, streptococci, pneumococci and viral diseases. Vaccines have at times given some promise, but with the possible exception of some known strains of influenza, the challenge to the research scientist still remains. The same may be said for the Coxsackie- and Echo-virus infections of the intestinal tract. In view of their extraordinary morbidity and at times high mortality, these diseases deserve the highest priority for research. Since their sole reservoir is man, eradication theoretically might be contemplated for some of these diseases.

OTHER VECTOR-BORNE DISEASES

Protozoa. The leishmanial diseases have *Phlebotomus* as vectors. Kala-azar reportedly has diminished spectacularly in India as a result of the residual-DDT house-spraying carried on by the National Malaria Eradication Service. Dr. A. P. Ray, in a personal communication, writes that certain States of India, including Uttar Pradesh, Bihar, West Bengal, and Assam, had many dispensaries and hospitals and an investigation center dedicated especially to the care of kala-azar. Now all of these establishments have been closed down because the incidence of kala-azar has become negligible and the few cases are cared for by the normal health services. The fragile character of the *Phlebotomus* and their limited flight capacity make these insects especially vulnerable to residual house-spraying. Unfortunately, dogs and other animals may harbor *Leishmania donovani*, so that consideration of eradication of the disease does not seem particularly feasible at the moment.

Cutaneous leishmaniasis and naso-oral or mucocutaneous leishmaniasis are also believed to be transmitted by various species of sandflies, *Phlebotomus*. A variety of rodents can harbor either *Leishmania tropica* or *L. braziliensis*. The frequency of acquisition of certain forms of the disease in forests and jungles would lead one to believe that eradication is currently improbable.

Chagas' disease is very important in many parts of South America and extends into Middle America. Mammalian hosts, other than man, are common reservoirs, so that the likelihood of undertaking eradication of the parasite is quite

remote. Malaria eradication programs have had some impact on the house-haunting triatomid bugs.

African human trypanosomiasis is rather rigidly confined to certain large sectors of Western Africa and to East Africa. The numbers of cases has fallen off considerably in recent years, but the cyclic tendency of the occurrence of epidemics suggests caution in forecasting future success. The occurrence of the human parasites in other mammalian reservoirs enhances the difficulty of eradication. Experimental work is in progress utilizing sterile insect releases for the control or eradication of tsetse flies.

Nematodes. *Wuchereria bancrofti* is widespread throughout the tropical world and is the cause of enormous morbidity. More than seventy species of mosquitoes of several genera have been proven to permit complete development of the filaria. Because of their breeding and other habits, a campaign for eradication directed towards interruption of transmission has not yet emerged. Primary emphasis on chemoprophylaxis with diethylcarbamazine has been recommended by the WHO Expert Committee on Filariasis (1962). Malaria eradication programs will no doubt have some impact, but a realistic forecast would indicate that eradication of this serious human disease may have to await further technological breakthroughs.

Onchocerca volvulus, in certain areas of Africa, is transmitted by *Simulium neavei*. The larvae of this blackfly breed in phoretic association with the freshwater crab, *Potamonautes niloticus*. DDT larviciding has been found to be very effective in eradicating the species from Kenya. No non-human reservoirs of this parasite are known. Unfortunately *Simulium damnosum*, the principal vector of onchocercosis in Africa, is not so vulnerable to attack. At present it would not be feasible to undertake global eradication of this disease.

Trematodes. With nearly 200 million people in the world infected with one of the three species of human schistosomes, and with the number increasing steadily as a result of utilization of water resources, the highest priority must be placed upon the development of control measures so effective that we might eventually contemplate an eradication campaign for at least *Schistosoma haematobium* and *S. mansoni*. Unfortunately, non-human mammalian reservoirs are frequently naturally infected in many endemic foci of *S.*

japonicum. Outlook for its eradication would seem to be rather dim. One cannot overemphasize the importance of underwriting a research program designed to fill in our gaps in knowledge concerning points of vulnerability in the schistosome life cycle and to develop more effective and safe therapeutic agents for radical cure of bilharziasis, cercaricidal agents, and more efficacious molluscicides.

Rickettsial infections. Epidemic typhus was, before the past few decades, one of the greatest human scourges throughout history. As a result of the development of DDT-dusting for the control of body lice, effective vaccines, and good therapeutic regimens, the disease has declined so that a total of 5,800 cases were reported in 1959. WHO Chronicle (1962) reported a further fall in incidence in many areas. Since man is believed to be the sole reservoir of this disease, it appears that it could be eradicated from the world with our current measures.

Other arthropod-borne viral infections. A large number of arthropod-borne viral infections afflict man in various parts of the world. More than 50 of these have been isolated and identified. A few of them have been responsible for seriously limiting man's activity, e.g. yellow fever, which was discussed above. During the past three decades the arthropod-borne encephalitides (mosquito-borne and tick-borne) have imposed serious threats within our nation and in other countries. Unfortunately, the occurrence of a wide variety of nonhuman reservoirs and of varied vectors make us very pessimistic about the prospects for eradication.

Borrelia infections. Spirochaetes causing relapsing fevers of man are transmitted by the human body louse and various species of ticks. Since wild rodents are known to be infected in nature, the prospects for eradication of the infective agents do not seem great.

BACTERIAL INFECTIONS

Bubonic plague. Bubonic plague, as a pandemic disease, disappeared long ago. The alarming epidemics in the port cities of the world associated with commensal rats have likewise disappeared. By 1960 only 412 cases were reported from the entire world, but WHO reported 1,457 cases of human plague and 121 deaths for 1964. When epizootics develop in pockets of the many wild rodents serving as permanent reservoirs, accidental cases occur among humans and small out-

breaks may result from either the bites of rat fleas or human fleas. Currently one cannot forecast that eradication of this zoonosis will be possible. For similar reasons, tularemia, on the basis of available procedures, would not be considered for eradication.

Asiatic cholera. Asiatic cholera, as a continuing endemic disease, is largely confined to Bengal in India, and to East Pakistan. It breaks out in epidemic form in a number of areas of Southeast Asia and adjoining regions. Recently El Tor has shown a tendency to spread. Apparently the vibrio finds great difficulty in perpetuating itself in areas with reasonable sanitation. Considering the current lack of sanitation in the areas of endemicity, eradication will not be feasible for a long time. Improvements in vaccines, in therapy, and in sanitation might change this picture in a reasonable period of time.

Oroya fever. Oroya fever (and verruga peruana) due to *Bartonella bacilliformis* is apparently restricted to man and the obligate vectors, *Phlebotomus* spp. Since these small flies are quite susceptible to our newer synthetic insecticides, and since various antibiotics have been highly successful in reducing the formerly high fatality rate, it would appear that this disease, of limited geographical distribution, could be eradicated.

Tuberculosis. Candau estimates that at least 15 million people suffer from infectious tuberculosis today, that more than 3 million die annually, and that between two and three million new cases arise each year.¹² These figures are disappointing when we reflect upon the dramatic decline in mortality from tuberculosis in most of the developed countries of the world during the past decade.

Frost boldly stated that for tuberculosis to be eradicated it was not necessary that transmission be immediately and completely prevented.¹³ Long before the development of effective chemotherapeutics he visualized the extermination of the tubercle bacillus, provided the number of infectious hosts is continuously reduced. This has been achieved in many localities in the United States, where in 1962 there were 672 counties (21.8 percent of over 3,000) with a population of 6,799,000 (3 percent of total) reporting 0 cases. Most of these zero counties were in the North Central Plains and Rocky Mountain States. In an additional 2,262 counties fewer than 10 cases each were reported in 1962. Some of our wisest experts in the field of tuberculosis believe that

the United States should *now* set a goal for the eradication of tuberculosis. The fact that it may take a few generations to attain should not prevent the adoption of the goal. The many small areas from which tuberculosis has already been eradicated should serve as foci, and their perimeters should be enlarged until these lacunae touch one another and coalesce into an ever-expanding sea of tuberculosis-free population.¹⁴

In developing nations BCG is extensively utilized. During the 1951-1960 decade the joint WHO and UNICEF vaccination program tuberculin-tested 309 million persons and vaccinated 117 million in 41 countries (WHO Chronicle, 15: 300, 1961). If the United States and other economically developed nations of the world make significant progress toward eradication of tuberculosis, then the global effort should be made.

Leprosy. Leprosy afflicts ten to twelve million individuals throughout the world. Suitable sulfone treatment regimens are available so that a majority of cases may be treated on an ambulatory basis and many of them rendered non-infectious. Since this disease is not nearly so infectious as is tuberculosis, and since no nonhuman reservoir is known to occur, it would be theoretically possible to eradicate it if a more effective and more rapidly acting chemotherapeutic were discovered. The chronicity and difficulty of early diagnosis would make total eradication difficult, costly and prolonged.

Pneumococcal and *meningococcal* infections would have high priority for attack when more effective control procedures evolve. The obligate human parasitic nature of the organisms provides encouragement.

MYCOTIC INFECTIONS

Man is heir to numerous infections due to various species of fungi. These organisms occur and multiply under variable conditions in the environment; only a few seem to be obligate parasites, and none are restricted to man. In our present state of knowledge it would be concluded that these organisms are not susceptible to eradication.

MISCELLANEOUS

The challenge of potential eradication of communicable disease is unfortunately limited. As indicated above, a number of man's important plagues are zoonoses which cannot be eradicated on the basis of our current knowledge.

Other diseases, including many respiratory and intestinal tract diseases associated with man's intimate ways of urban life, do not at the moment offer great hope of elimination. The development of efficacious immunization procedures or truly effective chemotherapeutic or chemoprophylactic measures cannot be excluded, but promising preparations are not on the horizon. In many of the infections of the intestinal tract, man's promiscuous defecation habits and other unhygienic propensities create a real obstacle to control and appear insurmountable as regards eradication. Human hookworm disease is an excellent example. In the past six decades this parasite has been eliminated as a public health problem from many of our previously endemic areas. Public health organizations have invariably encountered greater difficulty in changing the hygienic habits of people than in mass-immunization procedures, campaigns to control arthropods or other invertebrate vectors, and sanitary control of water, food and milk. Possibly new scientific breakthroughs will come to our aid and permit the establishing of a goal of eradication. This pessimistic statement is merely intended to stimulate research directed toward effective immunization procedures, more effective treatment procedures or environmental control.

Trachoma. Trachoma is the greatest cause of progressive loss of vision and blindness. It probably affects half a billion individuals. No country seriously affected by this disease can achieve industrial, educational or health development until the ravages of trachoma are restricted. Sulfonamides and antibiotics bring about control of the infection. Promising developments with vaccines are in progress. Since man is believed to be the only reservoir of this disease it would appear reasonable to assume that the development of an effective vaccine and improved therapy might make eradication a real possibility.

Syphilis. Syphilis retreated rapidly after World War II in areas where intensive case finding and treatment were effected. Since 1956 in the United States a substantial resurgence has occurred. More refined contact investigation, including specially trained investigators, has located and brought to treatment a higher percentage of exposed individuals. The Surgeon General of the U. S. Public Health Service was advised by his Special Task Force in 1961 that a direct, co-ordinated attack on infectious syphilis could stop its spread, and if the campaign were intensified for

10 years it would eliminate syphilis as a public health hazard in the United States. If such a campaign were successful nationally then true eradication could be contemplated.

Pinta. Pinta is not usually a very disabling disease, but it affects a half-million people in Mexico and four hundred thousand in Colombia. It is present in the Caribbean area and other parts of Central and South America. A single dose of 1.2 million units of procaine penicillin G in oil with 2 percent aluminum monostearate (PAM) is very effective. Eradication is a distinct possibility.

OUTLOOK

Global eradication of certain communicable diseases seems attainable. The membership of this Society and its parent societies have played a very significant role in evolving the concept of eradication. A few of the giants such as Gorgas, Stiles, Soper and Russell made practical application of the fundamental discoveries of Ross, Malcolm Watson, the Reed Yellow Fever Commission and many others. Great progress has been made towards world eradication of malaria, smallpox and yaws, and of the hemispheric eradication of *Aedes aegypti*, the urban vector of yellow fever. The development of international health agencies, of bilateral health agencies and foundations has made possible the undertaking of such vast campaigns.

Such technical breakthroughs as those by Weller (with his distinguished laureate colleagues, Enders and Robbins, and his more recent associates like Neva), Sabin and others make it possible for us to contemplate the potential eradication of measles, poliomyelitis, German measles and certain other human viral infections. The author recognizes the importance of the discoveries of our scientific colleagues from other countries, but on this special occasion is directing his remarks to our membership.

The philosophy of the eradication of communicable diseases, and the evolution of techniques for its achievement, should serve to stimulate our current membership in their investigative activities which may lead to discoveries providing the basis for more effectively attacking such major tropical problems as amebiasis, leishmaniasis, trypanosomiasis, filariasis, onchocerciasis, schistosomiasis and other trematode infections, viral diseases of the respiratory, intestinal and nervous systems, tuberculosis, Hansen's disease and others. Hopefully global eradication may be

initiated for a number of these within the next decade or two. Control is a continuing, costly procedure. Eradication is a one-time capital expenditure.

The degree of communicable-disease control which we wish to have prevail during the lifetime of our grandchildren will be determined by future scientific advancements and by administrative skill in their application. May we hope for a healthier future with global eradication of an ever-increasing number of man's plagues.

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