MEASLES ERADICATION: THE ROLE OF THE ANTHROPOLOGIST

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INTRODUCTION

In the Western response to infectious disease, priority has been given to preventive medicine and particularly to immunizations. The number of available vaccines is multiplying rapidly, and research directed at developing an even wider range of prophylactic agents is accelerating. Infectious disease continues to be the most important public health problem in the developing world, and vaccine-preventable disease is a cause of significant mortality and morbidity in these areas. Because the World Health Organization has called for the provision of immunizations to all of the world's children by 1990, it is likely that more anthropologists will be called upon to facilitate community acceptance of such programs. In addition to functioning as community mediators, anthropologists have other responsibilities with respect to immunization theory and practice. These include evaluating cost analyses, considering the legal and ethical aspects of immunizations, and examing the consequences of changes in epidemiological patterns in an evolutionary framework. It is also important to study the development of Western disease theory and associated practices in cultural and historical contexts.

HISTORY OF MEASLES AND VACCINATION

Over time, significant changes in human behavior have resulted in an increase in exposure to some diseases and decrease in incidence of others. The abandonment of a nomadic hunting and gathering lifestyle put populations in constant proximity to human wastes and other reservoirs of disease. Pastoralism brought humans into close contact with animals that transmit diseases which can become established in human populations. The development of agriculture and subsequent environmental modification created environments suitable for the multiplication of various disease vectors. Finally, urbanization and its associated high population density allowed the evolution of acute infectious diseases that are transmitted by person to person contact.

Measles belongs to this last category of disease. The initial measles attack generally confers a life-long immunity. Hence, even in a large urban community, epidemics have a relatively short lifespan, subsiding as the population of susceptible hosts decreases as a result of mortality and recovery. Only when new hosts such as infants and young children are available does the disease reach epidemic proportions again, attaining the status of a 'childhood' disease. However, when these diseases are introduced into virgin populations, all age groups are affected and morbidity and mortality increase drastically.

The attempt to trace the history of measles in ancient times is plagued by uncertainty, due to the difficulty of making conclusive diagnoses from the varying types of information given in historical texts. Measles was first distinguished from smallpox in 860 A.D. by Rhazes, although confusion between these two diseases persisted for centuries. There are numerous reports of devastating epidemics in the New World during the conquest and colonial periods. Despite the fact that trans-Atlantic contact began relatively recently, the identification of the diseases involved in particular epidemics is frequently a subject of debate. Difficulty in diagnosis sometimes arises from the fact that many infectious diseases show different clinical manifestations when they attack virgin populations. With measles and smallpox, many individuals die before the eruption of the characteristic rashes. Measles probably reached the New World in 1531, a decade after the arrival of smallpox (Dobyns, 1963:497).

Although the idea of contagion is ancient, and quarantine measures had been implemented in response to a number of epidemic diseases, the germ theory of disease did not gain acceptance in Western medical theory until the late 19th century. As early as 1546 Fracastoro gave priority to the theory of contagion, but the miasmatic theory, which attributed disease to polluting vapors that arose from swamps or decaying corpses, continued to prevail (Wain, 1970:95, McNeill, 1976:265).

In 1846, Peter Ludwig Panum observed a measles epidemic on the Faroe Islands. The unique circumstances provided by an island population that had been free of the disease for 65 years allowed him to make important conclusions about the epidemiology of measles. He determined that the incubation period was 13 or 14 days and that no cases occurred among those previously exposed. One of his most important conclusions was that measles was a contagious and not a miasmatic disease. Panum also describes some unsuccessful measles inoculation attempts he undertook in Edinburgh (Panum, 1940:94). As early as 1758, Frances Home had performed similar experiments with measles inoculation in Scotland (Waterson and Wilkinson, 1978:148).

The history of inoculation lends support to the idea that medical practice proceeds on an empirical line of development distinct from theories of disease. Deliberate exposure as a means of minimizing the mortality of an infectious disease has a long history. In China, three thousand years ago, an aerosolized smallpox 'vaccine' operated on the same principle as modern immunization. A powder was prepared from the scabs of an individual recovering from smallpox and introduced into the nostrils of a susceptible individual, a process known as variolation. The variolated individual would usually get a milder form of the disease followed by life-long immunity. Unfortunately, these individuals were contagious and could pass on the disease in its more severe form.

Variolation reached Europe in 1717 when the wife of the British ambassador to Turkey returned to England and introduced the practice. In 1796, Edward Jenner, himself variolated at age 8, performed an experiment which is seen as a hallmark in preventive medicine. Using material from the hand of a dairymaid infected with cowpox, he inoculated a susceptible young boy. He subsequently variolated the boy, who failed to develop smallpox, thus demonstrating the efficacy of the new technique which came to be called vaccination. The principles that allowed this technique to work were not understood at the time, although Jenner knew of the folk belief that those who got cowpox wouldn't get smallpox.

It was almost a century before the bacteriological work of Pasteur and Koch validated the germ theory of disease. Although the immunological principles underlying Jennerian vaccination remained undiscovered at this time, the demonstrated efficacy of the technique, combined with new knowledge of disease-causing organisms, gave rise to a number of attempts to develop prophylactic agents for other diseases. These attempts sometimes proceeded successfully in the absence of knowledge of the disease agents themselves. Pasteur himself developed and administered a vaccine for rabies in 1885, in spite of the fact that he was unable to isolate the infectious agent or grow it in vitro. The properties of filterable viruses were not understood for many years following successful vaccinations. The first virus was grown in tissue culture in 1913, and it was not until 1939 that the development of the electron microscope allowed these pathogens to be visualized (Hughes, 1977:77).

Knowledge about measles virus grew slowly in the first half of the 20th century. The fact that the virus is difficult to isolate from the infectious host (Fenner and White, 1976:394) was probably an important factor in this slow development. Credit for measles virus isolation has been attributed to Plotz in 1938 (Schmidt, 1959:292) and Enders and Peebles in 1954 (Fraser and Martin, 1978:1).

In current viral taxonomy, measles is assigned to genus Moribillivirus, family Paramyxoviridae. Like other members of the Paramyxoviridae; mumps, rinderpest, and distemper, measles is composed of a single strand of RNA. Antigenic and epidemiological characteristics of current measles strains have been used in attempts to reconstruct its origin. Because of the large population size needed to sustain measles transmission, most authors feel that measles is a relatively recent addition to the human repertoire of disease, appearing sometime after the agricultural revolution allowed substantial increases in population size and density. The range of possible earliest dates is extensive, and ranges from 10,000 BP (Cockburn, 1971:51) to 4500 BP (Black, 1982:398). Most authors feel that measles virus arose in the recent past and began with accidental transmission from the domestic animals that now exhibit closely related infections. Cockburn (1971:51) feels that canine distemper and rinderpest (cattle) are the likely culprits. The close morphological and antigenic relationships between these viruses and measles supports this interpretation. However, this evidence is ambiguous, since it also supports the hypothesis that as they became domesticated, the animals in question acquired these diseases from human. An implicit bias toward finding the cause of disease in 'nature' rather than in humans is evident in the philosophy of Western scientists.

CLINICAL ASPECTS OF MEASLES AND MEASLES IMMUNIZATION

Although measles produces highly consistent signs and symptoms, a number of host factors have been cited as causing clinical variation. As with most diseases, the determinants of clinical variation are not well understood. Age is the most important variable, with the highest fatality ratios and incidence of encephalitis being seen in infants and adults. Unlike many viral infections, measles has a higher mortality rate in malnourished populations (Fraser and Martin, 1978:3). Mortality rates as high as 38% have been recorded in West Africa, and there is evidence that the malnourished host is infective for a longer period of time (Morley, 1980:119, 125).

An attack of measles depresses cellular immunity, and may activate latent tuberculosis. The virus apparently has the ability to remain latent in the body for long periods of time. In a small number of individuals subacute sclerosing panencephalitis (SSPE), a chronic fatal infection of the brain, appears years after the initial infection of measles. Further mystery surrounds the possible relationship of measles virus to multiple sclerosis. Elevated measles antibody levels in MS patients were observed as early as 1962 (Shelley and Dean, 1981:74) but attempts to associate measles virus with this disease have not been totally successful. In recent experiments, parts of the measles virus genome have been isolated from only one in four MS patients (Haase, et.al., 1981:672). Some researchers have suggested that MS results from exposure to canine distemper (Norman, et.al., 1983).

The first measles vaccine to be developed was a killed vaccine, which approximately 800,000 people in the United States received before 1968 (Fulginitti, 1982:116). Recipients of this vaccine developed a high risk of suffering from a severe atypical measles syndrome when exposed to the natural disease or the live vaccine which is now in use, because the inactivated vaccine sensitized the host's immune system so it reacted to the live virus in an unusual manner.

The development and widespread use of an effective live vaccine has resulted in a dramatic decrease in reported measles in the United States. The risk of complications from the vaccine is estimated to be one case of encephalitis per 1,000,000 doses versus one per 2,000 cases of the disease (MMWR, 5/7/82:217,221). Cases of SSPE have also occurred after vaccination, but at a lower rate than with natural disease. It is not clear whether the risk of complication rises with age and poor nutritional status as it does with the actual disease.

Because of the existence of maternal antibodies, problems in establishing immunity in infants have been encountered. Measles vaccine is now administered at 15 months of age in the United States, and individuals who have been immunized prior to 12 months of age are considered inadequately immunized. However, in the developing world, the average child acquires measles much earlier, and many severe infections occur before age one. Because of the high mortality due to measles in the developing world, vaccination must be performed as early as 6 months to significantly reduce mortality (Ogunmekan et.al.

1981:177). When vaccine is administered this early, a large percentage will fail to develop immunity. Revaccination does not appear to solve this problem, as recent research has shown that children vaccinated at 12 months or younger did not respond well to revaccination, perhaps because of some immunological sensitization similar to that encountered with the killed vaccine (Black et.al., 1984).

IMMUNIZATION IN THE DEVELOPING WORLD

The success of the smallpox eradication program has generated additional enthusiasm for vaccination in a medical technology that has already placed an enormous emphasis on this form of disease control. In the United States, children are routinely immunized against diphtheria, pertussis, tetanus, polio, measles, mumps, and rubella. Additional prophylactics that may be recommended for international travel or high risk groups include typhoid, cholera, yellow fever, influenza, tuberculosis, hepatitis B, and plague vaccines. Other vaccines are in use or are in various stages of development, and a number of diseases have been suggested as candidates for control by immunization, including malaria, leprosy, schistosomiasis, herpes, AIDS, and cancer. Immunization is often considered when other methods fail to control a disease or are too costly. The appearance of malarial vectors that are resistant to various insecticides, as well as Plasmodia that are resistant to the effects of chloroquine, is well known. Malaria is not considered a good candidate for control by immunization because it can cause a persistent infection and the parasite changes its antigenic structure fairly rapidly. However, attempts continue to be made, and work on a leprosy vaccine has been accelerated by the fact that Mycobacterium leprae has developed resistance to one of the drugs that was most effective against it.

Most of the immunization programs in the developing world have the prevention of disease as their major goal. The rationale for such prevention has humanitarian as well as practical aspects. High rates of morbidity and mortality from infectious diseases are a significant barrier to economic development. Immunizations are considered one of the easiest health services to deliver (Creese and Henderson, 1980:494) and a successful program is believed to have a number of economic benefits. The following quotation illustrates this point of view.

> "It is widely accepted that successful vaccine programs, such as the one which essentially eliminated polio in the U.S.A., resulted in a ratio of $100.00 saving of public tax money per year for every dollar of expense of developing the vaccine, (i.e., based on estimated cost of hospitalization and institutional care for persons who would have otherwise developed polio in the absence of the vaccine, and the tax revenue obtained from individuals who reach maturity, had gainful employment, and thus became a taxpayer rather than a recipient."
> (Friedman, 1978:223)

Immunization programs have also been seen as having an important role in the acceptance of family planning programs. A guarantee of better infant survival is seen as a prerequisite for persuading people to have fewer children (World Health Organization, 1975:1).

Scientists interested in genetic variation between human populations have used immunizations to study the biological response to disease. Debate has centered around the reasons for the high mortality rates in virgin populations introduced to epidemic diseases. Some authors have stressed the role of social factors, pointing to the social disorganization and breakdown of patient care that occurs when everyone becomes sick at once. Others feel that genetic susceptibilities are responsible for high mortality. A number of researchers have administered measles vaccine to virgin populations of South American Indians in order to test these hypotheses (Neel et. al., 1970; Neel, 1982; Black et.al., 1982). Because the vaccine is in widespread use as a preventive measure, these experiments are not considered unethical. A small case of measles generally follows the injection, and the clinical and serological responses are recorded and compared to those of Western populations. However, this research has not yet resolved the issue of genetic susceptibilities.

Populations outside the developed world have often been involved in vaccine trials. Because new vaccines must be tested in the presence of the diseases they are to prevent, endemic areas must be used as test sites. Isolation from diseases is another criterion used in selecting a community as a test population. Some of the island populations in Micronesia have participated in studies to demonstrate the persistence of measles antibodies over time in the absence of the disease (Brown et. al., 1965; Brown and Gajdusek, 1970).

A number of epidemiological, geographical, technological and cultural factors can create difficulties in the administration of immunization programs in the developing world. Most vaccines have specific temperature requirements and lose their potency if subjected to temperatures that are either too low or too high. It is difficult to maintain the cold chain in areas where adequate refrigeration is lacking. Nomadic and migratory groups are difficult to locate and immunize adequately, especially when they cross national borders. Even in urban areas, identifying and locating migrant workers and other temporary residents present problems for immunization program staff.

A crucial determinant of the success of an immunization program is community acceptance. If a significant proportion of individuals do not receive immunizations, a program will fail regardless of how effectively logistic problems are handled. This is an area where anthropologists can play an important role. One prerequisite for community acceptance of a preventive health service is effective communication with the target population. The selection of appropriate channels of communication must take into account cultural and socioeconomic factors. In Nigeria, a mass media program failed because many women were engaged in trading and were not at home when the programs were scheduled (Odumosu, 1982:108).

Even with adequate communication, immunization rates may fall below desirable levels because individuals do not want to be immunized. Mackland and Durand (1976) have produced a profile of the factors relating to inadequate immunization in the United States. Their profile, based on interviews with parents, shows that a number of factors are correlated with low rates of vaccination. These are: low perception of disease seriousness, low perception of individual risk, inadequate knowledge of efficacy of vaccine, inadequate knowledge of length of protection, younger ages, lower education, larger families, less media exposure, and a greater percentage of non-whites.

In the developing world, studies of the characteristics of inadequately immunized populations have shown that Mackland's and Durand's profile does not have cross-cultural applicability. In Thamaga, South Africa, education of parents was not related to the child's immunization status, and lack of understanding of the reasons for immunization was prevalent in both the immunized and inadequately immunized groups. Many of those who had one immunization but failed to return for boosters believed that the practice was a ritual that would have lasting protective powers against all illness (Ulin and Ulin, 1981). The inability to understand why a healthy child should receive an injection showed a failure to distinguish between preventive and therapeutic health services, which is often cited as a factor in low acceptance of immunization. On the other hand, the successful use of penicillin against yaws in New Guinea generated support for a number of other injections (Radford, 1980:328). Undoubtedly there have been a number of instances around the world in which the belief that injections are beneficial facilitated acceptance of immunizations. Low immunization rates have also been attributed to distrust of free services and the belief that the practice is dangerous because of the fever and skin eruptions that sometimes follow the shots.

The administration of any vaccine involves a small risk of complications. Some vaccines create problems for individuals with allergies to eggs and other substances that may be present in small quantities in the vaccine. Often immunological sensitivities cannot be determined prior to vaccine administration. The occurrence of an allergic reaction or other vaccine-related complication in one individual in a small community may destroy the entire community's confidence in all immunizations. The determinants of participation in an immunization program are complex, and vary according to a number of different social, cultural, and historical factors. Methods for generating acceptance of immunizations must reflect the nature of these factors in each target population.

In addition to functioning as a troubleshooter concerned with increasing community participation in an immunization program, the anthropologist has a role to play in program evaluation. Funds for immunization programs are often justified on the basis of cost-benefit and cost-effectiveness analyses. A number of indirect and intangible benefits are quantified in cost-benefit analyses. Many factors render such analyses inappropriate in certain situations, for instance the difficulty of quantifying intangibles, the complexity and interdependence of the variables used, socioeconomic change, and differing epidemiological circumstances (McCarthy, 1979:410). There may be problems inherent in the application of cost-benefit analyses based on Western economic theory to non-Western societies in which values and economic circumstances are much different. Cost-effectiveness analyses simply measure the efficiency of competing programs and are preferred by some authors (McCarthy, 1979:411). By virtue of their close association with the communities involved and their understanding of daily activities related to economic productivity, ethnographers are in a position to evaluate the use of cost analyses in specific social settings.

For the applied anthropologist who acts as a community advocate and is concerned with establishing free choice and self-direction for the study population, the legal and ethical aspects of immunization are important considerations. Even in the developed world, there is controversy regarding this aspect of vaccine administration. Questions relating to the rights of individuals and the rights and responsibilities of those implementing immunization programs remain unanswered. The widespread use of immunization protects the population but puts a small number of individuals at risk for vaccine-caused disease and disability. Yet, when a significant number of individuals refuse immunization, the entire population may be susceptible to devastating epidemics that circulate among individuals who have not been adequately immunized or whose immunity has waned. Some of the legal and ethical questions that arise include the following: What type of informed consent is necessary? How are the possible risks to be explained to individuals with varying educational and medical backgrounds? Should individuals be compensated by society for complications caused by the administration of vaccines? Should parents who withhold immunizations from their children be penalized for negligence? There is no consensus about how to deal with the legal and ethical questions raised by vaccine administration.

MEASLES ERADICATION

The global eradication of smallpox graphically illustrates the power of human practices to affect the evolution of disease. In this case, the end result was the extinction of the variola virus. Because of the epidemiological similarities between measles and smallpox, some have suggested that measles may ultimately face a similar fate. However, most authors agree that the global elimination of measles, if it is at all possible, will be much more difficult than smallpox eradication because of a very important difference between the two viruses. Measles is one of the most contagious diseases known and its intrinsic reproductive rate (R_0) is much higher than that of smallpox. This means that a much higher level of immunity must be attained to break the chain of transmission.

The resilience of this disease is illustrated by the difficulties encountered in eliminating measles from the

United States in spite of high levels of immunity. In October 1978 a goal was set to eliminate indigenous measles from the U.S. by October 1, 1982. This goal was not attained, and no future target date has been set.

MEASLES INCIDENCE - UNITED STATES

Year	Total	Indigenous	Imported
1978	26,871	N/A	N/A
1979	13,597	N/A	N/A
1980	13,506	N/A	N/A
1981	3,124	N/A	N/A
1982	1,728	N/A	N/A
1983	1,436	1,136	300
1984	2,534	2,239	295

Source: Morbidity and Mortality Weekly Reports. Atlanta, Georgia, Center for Disease Control.

College campuses are frequently the focal points of epidemics. Individuals of college age grew up when measles transmission was decreasing because of use of the vaccine. Consequently their chances of acquiring the disease during childhood were low.

The number of people who remain susceptible to measles infection is not known. The group includes individuals who were not immunized because of refusal or medical problems. Immunized individuals may also remain susceptible because of vaccine failure, which can result from improper storage or administration (i.e., before maternal or other passively acquired antibodies have disappeared). Even with proper administration, the overall effectiveness of measles vaccine is reported at varying rates from 90% (MMWR, 12/17/82:659) to 95% (MMWR, 5/7/82:219). Consequently, even with 100% immunization coverage, 5-10% of the population may not be protected. Infants are considered protected against measles until 6 months of age because of maternal antibodies. No one has addressed the issue of what will happen when the vaccine cohort begins reproducing (as it already has) and infants fail to acquire passive antibodies from their still-susceptible mothers.

In the United States during the first 26 weeks of 1984, 51.6% of the individuals who acquired measles had been vaccinated before the first birthday, which is no longer considered adequate. These cases, along with 54 recruits at a Naval training station who were considered immune because of positive laboratory assays for measles antibody, were classifed as "non-preventable" (MMWR, 9/7/84:504). In spite of this, the Public Health Service's analysis and recommendations state only that efforts should be directed at increasing immunization coverage.

Controversy is beginning to surface over whether measles cases in vaccinees results from initial vaccine failure or from waning immunity (Black, 1982:413). If the vaccine does not confer a solid life-long immunity, current immunization policies providing a single dose will need to be altered. Otherwise, when the first generation of vaccine recipients reaches old age, if measles has not been totally eradicated, it may emerge as a geriatric disease, where it is likely to be particularly severe.

The question of waning immunity is also important in evaluating the possible epidemiological effects of subclinical cases. The fact that the decline in antibody titers is greater in the absence of epidemic measles illustrates that subclinical infections do take place (Fraser and Martin, 1978:3). While such infections are not generally considered communicable, research in Nigeria has suggested that subclinical infections in adults may be transmitted to susceptible children (Harry, 1981:172). If this phenomenon does occur, it can be expected to increase in populations where antibody titers are low because of waning artificial immunity.

It is clear that immunization has had an effect on the epidemiology of measles. The disease has 'evolved' in the U.S., where it has been transformed from a common childhood illness into a disease which causes sporadic epidemics among young adults. This is a result of the fact that vaccination imposes selection pressures on the pathogens that infect human beings. Disease agents such as measles virus, which are viable only in the human organism, are particularly susceptible to such selective pressures. However, when a disease agent has a high reproductive capacity, the outcome of selection may not be extinction, but evolution.

A conservative estimate of the rate of spontaneous mutation in viruses is one per 1,000,000 replications. Because replication occurs several million times in a single host, mutations occur during each episode of a viral disease, including subclinical infections (Fenner and White, 1976:72). Under natural conditions most of the mutations that arise have to compete with the established form of the disease. Such competition is unsuccessful unless the variant possesses a selective advantage. When the original form is unable to succeed in establishing infection in new hosts because of immunity, forms that can invade and multiply in spite of host defenses will be favored. Mutations that increase a virus' invasive ability, alter its antigenic structure, or suppress immune responses may emerge. Optimism about the elimination of measles is based on the assumption that the virus is antigenically stable. However, immunoselection using monoclonal antibodies has shown that antigenic variants of measles virus arise spontaneously in the laboratory (Birrer et.al., 1981).

CONCLUSION

A final responsibility of anthropologists involves investigating the customs and practices of our own society. This field of study has not received the attention it deserves. We must recognize that modern medicine is a cultural system, and as such operates on the same principles as the cultural systems of other societies. Such a system is associated with a number of customs and practices that have evolved in response to various stresses. The form these practices take is determined by historical precedent as well as economic and practical consideration. A cultural system does not have foresight, and some of its 'adaptive responses' may not be favorable in the long term.

The logical outcome of the widespread use of vaccination may be to produce a pathogen that can interfere with the host's immune response in some manner. The idea of a communicable disease agent that can literally 'turn off' an individual's immune system is no longer hypothetical. Such a disease has already reached alarming proportions in the United States, where it has been diagnosed in 8215 people and caused 3929 deaths (as of February 4, 1985). The recent appearance of this new disease, presently termed Acquired Immune Deficiency Syndrome (AIDS), and the linking of many viruses to malignancies, suggests that demographic transition theorists need to start over. The battle against infectious disease has not been won. In fact, it may have just begun.

> "Infectious disease which antedated the emergence of humankind will last as long as humanity itself, and will surely remain as it has been

hitherto, one of the fundamental parameters and determinants of human history."

(McNeill, 1976:291)

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