



VARIOLA MAJOR'S last case Rahima Banu, a little girl in Bangladesh who survived.



AFTER RECOVERY, Ali Maow Maalin, will have chance for normal life.

Global Effort Pays Off.. Smallpox at Target "Zero"

The last documented, naturally occurring case of smallpox was diagnosed in Merka, Somalia, in 1977. On October 26, 1979, the world celebrated its second anniversary free from smallpox transmission.

Ali Maow Maalin, then 23, was a cook in Somalia when he came down with smallpox. When he recovered, he became the last recorded case of variola minor, a less severe form of the viral exanthem.

Variola major was snuffed out earlier in 1975 with the recovery of Rahima Banu, aged 3, of Bhola Island, Bangladesh.

The campaign against smallpox was made possible by many things — perhaps most important was the mustering of international will to conquer a common pestilence. The international will to eradicate smallpox was assisted by new developments in technology and by the development

of confidence among a trained army of smallpox fighters from most of the nations of the world — confidence that they could be successful in combat with an old enemy.

In 1967 WHO launched the global Smallpox Eradication Programme to rid the world of the disease within 10 years.

The program followed several less extensive, but notable successes. Eight years earlier, WHO had suggested the program to the council of nations at the instigation of the Soviet Union. At that time, several nations began vaccination programs and in many, endemic transmission of smallpox

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Zero Smallpox Issue

This issue of DATELINE: CDC is devoted to the story of the eradication of smallpox and CDC's involvement. Inside stories include:

- Historical vignettes
- Pictures of field work
- The last case of U.S. smallpox
- An early campaign to eliminate the disease
- Technology of eradication
- Future of the smallpox virus
- Chronology of smallpox, and others

Throughout this issue are scattered stories of "unsung heroes" from many nations who worked with CDC staff in the fight against smallpox. We have asked the staffers who worked with them to write about them, and all represent true stories of the eradication battle.

Physicians Challenged Smallpox in 1844

The WHO campaign against smallpox wasn't the first time war had been declared on the disease.

In 1844 the progress of a vaccination program in India was summarized in this way:

"...It was absolutely necessary to the final establishment of vaccination, that it should be carried to the doors of the people — too lazy, too poor, or too ignorant, to come in search of it. He (the Hon. Mounstuart Elphinstone) was well aware that the presence of a European officer thoroughly versed in the manners and habits of the natives, would do more to

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CHIEF, EPIDEMIOLOGY TRAINING
INSTRUCTIONAL SERVICES DIVISION
BUREAU OF TRAINING
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Editorial and Distribution inquiries to

DATELINE:CDC
Room 2071
Building 1
Center for Disease Control
Atlanta, Georgia 30333
Ext. 3444 or 3286

Technology, Determination Win Against Implacable Enemy

The conquest of smallpox has primarily been a human accomplishment — a dramatic example of the good that can be done whenever enough people turn toward a single goal.

But any review of this medical milestone must also note the important role played by technology.

Three technological tools were particularly vital: the jet injector gun, the bifurcated needle, and freeze-dried vaccine.

The Jet Injector Gun

The jet injector gun traces its beginnings to a 19th century industrial accident. But it took half a century for it to evolve from mechanic's tool to medical instrument.

French workmen of the 1890's, who used grease guns in factories, complained about injecting themselves instead of their intended targets with grease.

Later, biomedical researchers went to work to find a practical, portable, and effective variation on the principle of the grease gun to inject a jet of immunizing liquid at high pressure and velocity through the skin.

For more than 20 years, in this country, the jet injector had been used to give shots to large numbers of

people at one time, particularly in the military.

But it received major use in smallpox in the early days of the smallpox eradication program. Injections against smallpox, measles and other diseases were given at an average cost of 7/10ths of a cent, in West Africa. In Brazil more than 90 million smallpox vaccinations were given by jet gun.

The Bifurcated Needle

While the jet injector gun was effective in administering smallpox vaccine to large numbers of people at collected points, it was unsuitable for house-to-house vaccination programs. The guns required maintenance and repair that could not always be provided.

In 1967 the program began experimenting with the new bifurcated — or forked — needle. (See illustration.) This was one of the simplest items of medical technology, but it was to play a major role in delivering vaccine.

The bifurcated needle has two
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Texas Man Survives Last U.S. Smallpox

No one knows for sure when and where the last case of smallpox in the United States occurred.

The best guess, based on a retrospective look at national reporting, indicates that it probably was in 1949 during an outbreak of smallpox in the lower Rio Grande Valley, Texas.

Small numbers of smallpox cases were reported in the early 1950's, but these did not have laboratory confirmation, and are believed to have been an illness that was clinically suggestive of smallpox, such as chickenpox.

Abdel Gadir el Sid

by Dr. Stanley O. Foster

Abdel Gadir el Sid, a Sudanese smallpox operations officer, arrived in Somalia at a time when smallpox case hiding by the public was the rule.

Giving his translator the afternoon off and communicating in his native Arabic, Abdel Gadir moved from village to village searching for smallpox. Suddenly he found a single case. When villagers denied other cases, Abdel Gadir had an idea. He told his driver that he would drive and purposely drove the vehicle into two feet of mud.

Villagers poured out of the houses to push the mired vehicle. Among them five more cases of smallpox. The hidden cases had been detected.



VICTORY SMILES for four who were prominent in smallpox eradication when last case occurred in India: Dr. J.D. Millar, Jim Hicks, Dr. William Foege, and Billy Griggs. At center is smallpox god, also defeated.

An Historic Chronology of Smallpox and Its Final Eradication

- SOMETIME B.C.** The practice of variolation developed in several areas; scabs or matter taken from pustules were rubbed on the skin of normal individuals, causing a mild infection.
- 910 A.D.** The first complete medical report on smallpox, *Treatise on Smallpox and Measles*, was published by an Arabian scholar, Rhazes.
- EARLY 1500's** Smallpox was probably introduced to the New World by slave ships.
- 1618** The first smallpox epidemic to strike the Indians in American colonies north of Mexico occurred in the area surrounding Boston.
- 1682** Thomas Sydenham, British physician, in a treatise on smallpox criticized the widely used heat treatment that made patients miserable, and observed that the survival rate was higher in the untreated than in those kept in a "hot bed."
- 1721** Lady Mary Wortley Montagu, who learned about variolation while in Turkey as wife of the British ambassador, introduced variolation to England. Princess Caroline accepted it for her children, and the practice became widespread.
- 1746** Renewed interest in variolation led to the establishment of the Smallpox and Inoculation Hospital in England. Improved procedures lowered the mortality rate. The practice spread to Europe and Russia. Robert and Daniel Sutton, father and son, further refined the variolation technique, in part through selection of healthy patients.
- 1776** The American colonial army lost a battle for Quebec to the British, largely because of smallpox. The British were immune. The Americans were not, and came down with smallpox.
- 1796** Sarah Nelmes, a milkmaid, contracted cowpox. When the sores on her hand were at the worst, Edward Jenner vaccinated a boy, James Phipps, with material from the sores. James became permanently immunized against smallpox.
- 1798** Dr. Jenner published his findings on vaccination: *An Inquiry into the Causes and Effects of the Variolae Vaccinae; A Disease Discovered in Some of the Western Counties of England, Particularly Gloucestershire, and Known by the Name of the Cow Pox.*
- 1802** Benjamin Waterhouse, a Boston physician, proved the safety and effectiveness of the smallpox vaccine. He vaccinated a large number of children, and later exposed them to smallpox. None became infected with smallpox.
- 1802** Thomas Jefferson, who had been interested in Jenner's and Waterhouse's work, wrote that the practice of inoculation should be brought "to the level of common capacities." He allowed the use of the White House for distribution of smallpox vaccine and made special efforts to ensure vaccination of American Indians.
- 1802** King Carlos IV of Spain agreed to finance an expedition to vaccinate the Indians in Central America. Led by Francisco Xavier de Balmis, the expedition brought vaccine to hundreds of thousands of Indians and later to the Philippines and other Spanish colonies.
- 1806** Thomas Jefferson wrote to Jenner: "Future nations will know by history only that the loathsome smallpox has existed and by you has been extirpated."
- 1813** Congress authorized President James Madison "to appoint an agent to preserve the genuine vaccine matter, and to furnish the same to any citizen of the United States."
- 1832** Congress passed an act ordering the Secretary of War to supply pure vaccine to Indian agents for vaccination programs.
- 1834** Negri in Naples produced good quality calf lymph by infecting healthy cows. This made human-to-human vaccination unnecessary.
- 1900** By the turn of the century, the widespread use of vaccines had turned smallpox from a major threat into a minor one in the United States and most of Europe, except Russia.
- 1923** The Russian government made smallpox vaccination mandatory.
- BEFORE 1930's** The Dutch and the French were using vaccines in their colonies.
- 1947** An imported case of smallpox in New York City led to five cases and vaccination of 6,000,000 in New York. Surrounding areas also had vaccination campaigns. It was the first smallpox in New York City since 1939.
- 1949** The last known case of smallpox in the United States occurred in Rio Grande valley, Texas.
- 1950's** Freeze-dried vaccine was developed by Leslie Collier of the Lister Institute in England. The vaccine was frozen in a vacuum and reconstituted with glycerol solution. This was an important step in making a worldwide eradication program possible, because the vaccine could last two years at body temperature.
- 1958** WHO received, at a World Health Assembly meeting in Minneapolis, Minnesota, a Russian resolution that smallpox could theoretically be eradicated.
- 1959** Meeting in Geneva, the World Health Assembly passed the Russian resolution. A few nations began eradication programs, but it was to be several years before a concerted worldwide program would get under way.
- 1961** CDC began smallpox surveillance and began considering how to handle a possible epidemic if one occurred.
- 1962** A boy traveling from Brazil to Canada passed through New York City. He came down with smallpox in Canada. CDC coordinated a wide-reaching immunization effort to vaccinate all possible contacts.
- 1962** CDC started studies of the smallpox vaccination status of hospital workers.
- 1963** CDC established a smallpox unit in its Bureau of Epidemiology.
- 1963** CDC sent a vaccination team to Tonga in the South Pacific to test the U.S. Army's hydraulic jet injector in a population that had not received smallpox vaccination. The jet injector proved capable of giving the vaccine intradermally at the rate of 1,000 injections per hour.

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An Historic Chronology of Smallpox and Its Final Eradication

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- 1963** The Bureau of Biologics tested a new measles vaccine in Upper Volta, using jet injectors to vaccinate over 10,000 children. This program and later measles programs in African nations were sponsored by the Agency for International Development (AID).
- 1964** CDC began investigating the question of whether or not to continue smallpox vaccinations in the U.S. Smallpox was gone in the United States, and there was a need to determine the extent of reactions or deaths from smallpox vaccine.
- 1965** CDC proposed a joint smallpox eradication and measles control program in West Africa to AID.
- 1965** After a representative of one African nation praised the measles programs to President Lyndon Johnson, the President issued a statement to the World Health Assembly pledging more U.S. assistance to vaccination programs in Africa, and the eradication of smallpox. This paved the way for the 20-nation smallpox eradication/measles control program that CDC had proposed.
- 1966** CDC began organizing and training teams of medical officers and operations officers for two-year tours of duty in 20 West African nations with an estimated population of 150 million.
- 1966** Lagos, Nigeria, was selected as the West African headquarters of the project.
- 1966** The World Health Assembly voted to establish a Worldwide Smallpox Eradication Programme, appropriating \$2 million to get started.
- 1967** The first vaccinations began in the West African project.
- 1968** After mass vaccination failed to eradicate smallpox in some areas, the CDC group developed a surveillance and containment system. They used this system in eight countries: Nigeria, Togo, Dahomey, Mali, Upper Volta, Niger, Guinea, and Sierra Leone.
- 1968** Surveillance and containment was introduced into a WHO-sponsored smallpox eradication program in Indonesia.
- 1970** The last case of smallpox occurred in West Africa.
- 1971** The last case of smallpox occurred in Brazil.
- 1971** The Public Health Service accepted the recommendation of its Advisory Committee on Immunization Practices that routine smallpox vaccination be discontinued. For most people in the United States, the probability of contracting smallpox was so small that the risk of complications from vaccine outweighed the benefits derived from it.
- 1971** A decision was made to spend HEW funds to further smallpox eradication. Previously all money was from the Agency for International Development.
- 1972** A pilgrim returning from Mecca is believed to have imported smallpox into Yugoslavia. An epidemic followed, involving 174 cases, with 36 deaths. CDC assisted in vaccination of an estimated 16 or 17 million people in a population of 21 million.
- 1973** The Indian government requested the states to start offering rewards to individuals who reported cases of smallpox. Rewards were eventually extended to health workers. The rewards were necessary and helped prove to those reluctant to report that the government really did want cases reported.
- 1973** Surveillance and containment was begun in India. This led to such an improvement in reporting that many thought India was having a smallpox epidemic.
- 1975** Saiban Bibi, a young woman from Bangladesh, was the last case of smallpox to occur in India. She became infected in Bangladesh and traveled to India. She left in her wake thousands of searches for cases among possible contacts, and hundreds of vaccinations, but no more cases of smallpox. She recovered and returned home.
- 1975** The last case of smallpox in Asia, and the last case of variola major, occurred in Bangladesh. The victim, who recovered, was a little girl, Rahima Banu.
- 1977** On October 26, the last case of variola minor to occur in the world, occurred in Somalia. The victim, who recovered, was Ali Maow Maalin.



TRAINEES AND FACULTY at CDC before launching West African Program.



PEOPLE IN LINE for vaccine in 1967 at Ghana Trade Fair.

"Zero" (From page 1)

was interrupted. Smallpox remained where there were large rural populations, poverty, poor transportation, and poor communications.

Vaccination had eliminated smallpox from Europe and North America, but it was still a major problem in parts of South America, Africa, and Asia, and thus posed a continued threat to smallpox-free areas. In 1966 smallpox was endemic in 30 countries and afflicted more than 2.5 million people.

In 1965 the U.S. pledged its support of the eradication concept and other vital developments came along soon thereafter to make the time right for eradication. According to those who worked in the program, those developments were:

1. The pooling of international resources in a coordinated effort
2. Improvement of the technique of vaccination
3. Introduction of high quality freeze-dried vaccine
4. A change of strategy from one of mass vaccination to one in

which surveillance/containment were the principal components.

The campaign and its success have special meaning for CDC. In 1966 the U.S. supported eradication projects on a regional and bilateral basis with 20 countries in Africa. Under contract with AID (Agency for International Development), CDC was designated to provide personnel and orientation programs for a preliminary skirmish against the disease in West and Central Africa.

That year it was estimated that some 200,000 to 400,000 cases of smallpox occurred in West Africa in most years. Obstacles to the eradication program included lack of adequate transportation and communication systems, insufficient medical organization and personnel in many countries, and cultural differences.

The jet injector gun was used in the African campaign and was a new, sometimes frightening tool to villagers wary of vaccination of any kind. In each of the 20 countries of West and Central Africa, an American medical officer and/or American operations officer were responsible for working

Dr. Foli Georges Glokpor

by Andrew N. Agle

In the spring of 1969, Dr. Foli Georges Glokpor, director of the smallpox program in Togo, submitted a carefully researched report on cultural resistance to smallpox vaccination in Togo. The report, prepared at the request of CDC, was expected to detail the pagan activities of the Sakpate cult whose members considered smallpox sacred (and, by logical extension, presumably regarded vaccination as a threat).

Dr. Glokpor presented a detailed exposition of the cult's history and tenets. He traced the cult's activities right up to the date of his report. He concluded that, although there were indeed some Sakpate adherents who had avoided being vaccinated, the only modern day "cultural resistance" on a village-wide scale had occurred (on two occasions) in villages whose inhabitants had been proselytized by an obscure Christian sect.

 with the local governments. They assisted in planning the program and worked closely with the Ministry of Health in seeing that each country had a plan suited to its own human, financial and other resources.

"It seems to me that this early part of the program was pivotal from the standpoint of CDC," said Dr. J. Michael Lane, one of the Center's lead people in the smallpox effort. "It was Dr. David Sencer's decision to commit CDC resources and people to the smallpox program that made all of the rest possible."

Dr. J. Donald Millar, director of the African Program, emphasized that the success in Africa was largely because it was an African program. It was planned by the Africans and carried out by Africans except for the input of the American officers in each country. It is estimated that about 4,000 Africans worked in some capacity.

In Africa an important tactical change was made—a change which was to set the example for the global attack on smallpox. Previously fighters

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of smallpox had believed that the answer to eradication lay in mass vaccination of populations—saturation or "herd" immunity.

This approach had been used in Jamaica, Tonga, and parts of Brazil in an earlier project supported by WHO and the Pan American Health Organization (PAHO). It had been used for most of the 170 years since development of smallpox vaccine.

But, in Africa epidemiologists learned interesting new things about smallpox. Among them:

1. Smallpox spread more slowly from person-to-person than had been believed traditionally. This meant that if smallpox can be found in a community, there is time to stop its spread.
2. Smallpox struck only certain villages in any one year, and even during epidemic periods often fewer than 1 percent of all villages were involved.
3. Smallpox outbreaks occasionally occurred in well vaccinated populations.
4. Smallpox outbreaks could often be controlled with very small numbers of vaccinations.

This led to the strategy of surveillance/containment. Through surveillance, villages with smallpox were identified. Patients with smallpox in the villages were isolated, and people in surrounding villages were vaccinated so smallpox would not spread to them. With this technique, transmission was interrupted.

Dr. William H. Foege, in Africa at the time, conceived and developed the strategy initially because of a shortage of vaccine and resources. According to Dr. D. A. Henderson, assigned by CDC to WHO, where he directed the international eradication effort: "There was a delay in the delivery of supplies for the mass-vaccination program in eastern Nigeria, and an energetic U.S. advisor, William H. Foege, organized an interim program: he searched out smallpox cases and vaccinated thoroughly in a limited area surrounding each case."

Another major technical change came later with the introduction of the bifurcated needle. The practical,

efficient tool made vaccination procedure in the field more successful than ever before.

But always, it is the international cooperation which smallpox fighters remember and which most talk about.

"If vaccinators from one country needed to cross the borders of other countries in pursuit of smallpox, they were permitted to do so without any problem," said Jim Hicks, regional administrative officer in Lagos.

The smallpox eradication program in Africa was completed in 1970, three-and-a-half years after it began and ahead of schedule.

By the 1950's, smallpox had been eradicated from North and Central America. In 1966, when WHO was calling for its global program and international support, Brazil was the only remaining country in Latin America with smallpox. As a result, it became the focal point of a concentrated effort to eradicate the disease in the Americas.

Brazil's population of 100 million people equals that of the countries of West and Central Africa. In 1967 the campaign to eradicate *variola minor*, the type of smallpox found in Brazil, was begun.

That year, 4,000 cases of the disease were reported. Leo Morris, who served as a consultant with the Brazilian government on the program, later estimated that the number of cases of smallpox was closer to 200,000 than 4,000. The team in

Brazil set up weekly reporting systems and surveillance networks and helped train physicians to set up surveillance/containment units throughout the country.

Brazil invested \$1.2 million in the smallpox eradication program, during which 94 million people were vaccinated between 1967 and 1971. By 1969, when 7,000 cases were reported, the strategy changed from mass vaccination with jet injector to surveillance/containment and use of the bifurcated needle. After the change, smallpox was stopped in one state after only 50,000 people out of seven million had been vaccinated.

Brazilian physicians, trained in their own nation's program, later assisted the WHO program in Ethiopia, India, and Bangladesh. By that time, much of the vaccine being used in the program was produced in Brazil.

Indonesia, which had eradicated smallpox under the Dutch prior to World War II, had it reimported by the Japanese after 1942. At the time of the Indonesia phase of the WHO campaign, Dr. Lane was actively participating there.

"Communication was one of our major hurdles," he said. "There were no standardized reporting forms for smallpox among the islands before 1968. It made it difficult to know where smallpox cases were located."

When reports were simplified and standardized, they came in regularly



SMALLPOX SEARCHER Dr. Ali Mourad of Egypt displays photo of smallpox cases. Bangladesh.



RECOVERING CASE (center) with Dr. Ronald Waldman and Dr. Stephen Jones.

and accurately. When reports were not received, the Indonesia Communicable Disease Center in Jakarta delegated someone to find out why and do something about it. Such reporting made the surveillance/containment phase possible in Indonesia.

"The Indonesians were enthusiastic about their work," said Dr. Lane. "They have a strong tradition of epidemic and disease control." One group of young Indonesian workers was given large credit for eradicating smallpox from the Riau Islands, a task once thought impossible by some. By 1974 no cases were reported and WHO declared Indonesia free of smallpox. It, too, sent technical aid and experts to other parts of the world to continue the global battle.

The story of smallpox eradication in India is one of cultural nuances, economic stringencies, and dogged determination on the part of Indian and WHO health officials. In 1975, after an eight-year campaign, India reported its last case of smallpox.

In 1962 a mass vaccination campaign was begun and more than 500 million people were vaccinated in five years. In 1967, when WHO began its India push, there was as much smallpox as before in spite of the previous vaccination program. Among the reasons:

1. The same people had been vaccinated over and over the first time around. Some school children were vaccinated three and four times.

2. The lower income groups were not reached in many cases.
3. The vaccine being used was not stable enough to give adequate protection.

In 1973 India was successfully using surveillance/containment procedures in some states and was in the process of switching the rest of the national program from mass vaccination to surveillance/containment.

Among the first steps of the overhauled program was to set up training programs to get unified surveillance systems working in high-risk areas — West Bengal, Uttar Pradesh, and Bihar.

Team members talked to school children and teachers, people in the market place, and in other key areas. By late 1974 surveillance teams were conducting house-to-house searches for smallpox, averaging 30-million houses per month in high-risk areas.

Each district medical officer listed high-risk areas and people in his district, including minority groups, and lower socioeconomic groups. Each month a special team then went into these locations to search for smallpox.

When an outbreak was discovered, all households within a 10-mile radius were searched.

To assess the effectiveness of the surveillance/containment program, a team was sent out a few days or a week later to see if villages had been searched and to determine if the source of infection had been found

and if containment had stopped the spread.

WHO had international epidemiologists working under the direction of the Central Government of India. The government also provided epidemiologists and six or seven central appraisal officers to work with the states; actual responsibilities for the program were vested in state and district health officials.

The Indian Minister of Health requested frequent status reports from the states and his smallpox program director or central appraisal officers attended all state meetings.

"An equal level of dedication would be hard to find," said Dr. William H. Foege, who headed the India program from 1973-1975.

During 1974 when over 100,000 cases of smallpox were reported, India's Central Government decided to continue and intensify efforts during the monsoon season — declaring that no village was inaccessible.

Dr. Mary Guinan, assigned to the state of Uttar Pradesh, one of the worst smallpox areas of the country, visited out-of-the-way villages during the 1974 monsoon season. In one village, reportedly free of disease, she found an unreported outbreak. After a round-trip journey through many obstacles to Lucknow, she reported the outbreak and collected supplies to be taken back to the field the next day. Returning to the village with food, supplies, vaccine, needles, and sleeping bags, she and the Indian health workers vaccinated everyone within 24 hours and searched all houses within a 10-mile radius.

"Travel during the rainy season was a challenge," she said. "We sometimes rented camels for 24 cents to take our supplies across the river. Sometimes I was carried on the shoulders of two villagers while I still sat on my bicycle. We used ox carts and often carried supplies on our shoulders so as not to get them wet."

Commenting on the reactions of the villagers, Dr. Guinan said, "They were so busy just surviving that they couldn't see the grand plan of smallpox eradication."

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Scientific Community Must Proceed with Research about Smallpox, Related Viruses

Reprinted from New York Times

by Harold Schmeck

ATLANTA—In three drab freezer chests in a laboratory near Atlanta are more than 300 specimens of the most bizarre and malevolent endangered species on earth.

The laboratory, at the Federal Government's Center for Disease Control, is one of the last refuges of a living thing that has killed millions of humans and has spread panic and destruction for thousands of years. It is the virus that caused smallpox.

Stored in little glass vials at 94 degrees below zero are specimens from many different years and places, from deadly outbreaks in which almost half of the patients died and from others that were relatively mild.

The Center for Disease Control has samples from the last smallpox outbreak in Bangladesh, in 1975; from the last outbreak in India, the same year, and from what may prove to have been the last case of smallpox on earth—in Merka, Somalia, last October.

Eradication Believed Likely

Public health experts think it likely, though not proved, that the smallpox virus has already been eliminated on earth.

Even if the disease proves to be finally eradicated, however, research will continue. Experts will also need to refer to laboratory specimens in the event of some future outbreak similar to smallpox.

In view of the possibilities of new smallpox outbreaks, the World Health Organization, which has run the decade-long campaign to eradicate the disease, has asked nations to maintain stockpiles of vaccine.

The United States already had almost enough bulk vaccine stockpiled at Wyeth Laboratories facilities in Marrietta, Pa., to protect 200 million people. Kept at low temperature in a freezer room, the vaccine is believed to have an almost indefinite lifetime. In an emergency more vaccine could be prepared fairly quickly.

A year ago, at least 17 laboratories throughout the world kept the smallpox virus. Since then the World Health Organization has persuaded many to destroy their specimens.

The objective is to have no more

than four, perhaps only two, laboratories in the world as repositories for the virus. One will be at the Center for Disease Control, which has played a major role in the world eradication effort. Another will probably be a laboratory in Moscow. If there are four, the remaining two will be in London and Tokyo. At present, scientists at the Center for Disease Control do most of the world's laboratory diagnostic work on smallpox—testing each new suspect sample to determine whether it is really smallpox virus.

The preserved virus samples are kept under lock and key in a laboratory that few people are allowed to enter. When no one is in the laboratory, the whole area is bathed in the baleful blue glow of ultraviolet light intense enough to kill an escaped virus.

Vaccinations Required

No one may enter the laboratory without proof of a successful vaccination in the last three years. Those who work there regularly are vaccinated yearly.

The air is filtered continuously and the air pressure is kept slightly below that of the outside atmosphere so that air flow, except through the filters, is always inward.

Nothing leaves the enclosure without being carefully disinfected. Every person who goes in must shower before leaving and blow his or her nose to eliminate anything lodged in the nasal passages. Only laboratory clothes can be worn inside, and every garment is sterilized after use.

The dread virus has not been found anywhere outside a laboratory since the case in Somalia, a young man who has recovered. But no one can be certain that he was indeed the final victim, and specialists at the C.D.C. say the war over the Ogaden has hampered surveillance, especially on the Ethiopian side.

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prongs that can be dipped into the vaccine. They hold the right amount of vaccine in a space between the two prongs by capillary action. As long as the person using the needle always vaccinates with a perpendicular motion, people with a minimum of training can get 95 percent "take" rates consistently.

The bifurcated needle was developed by Wyeth Laboratories, Philadelphia, which allowed the eradication program to use it without patent costs. It became a basic tool in the program, and enabled a vaccinator to give up to 1,500 vaccinations a day.

Freeze-Dried Vaccine

Potent vaccine which is stable at high temperatures is an essential element in any effective immunization campaign. The provision of such vaccine for the smallpox eradication program was particularly difficult because of special problems related to temperature, storage, and transportation.

Freeze-dried vaccine seemed ideal for this program since it did not require refrigeration. The technique for producing freeze-dried smallpox vaccine had been devised in the early 1950's at the Lister Institute in

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IN DACCА headquarters — Dr. Stan Foster communicates by radio with field staff.



IN BANGLADESH MEETING — Dr. Jay Weisfeld (center) of CDC with Dr. Ollie Ringertz (left) of Sweden and Dr. Bert Van Ramshorst of Holland.

Simon Pierre N'dengue by Robert J. Baldwin

One of the unsung heroes of the smallpox eradication effort in the United Republic of Cameroun was Simon Pierre N'dengue. Simon served as the Program Manager during my stay in the country between 1970 and 1972.

Simon, who had been with the program since its initiation, was one of the most versatile and resourceful persons with whom I've ever worked. He was literally a jack of all trades. He could repair almost any Ped-O-Jet or vehicle brought to him and was quite imaginative in adapting when parts were either in short supply or were non-existent. In addition to persistence and ingenuity in this area, he was able to effectively teach these skills to other persons in country as well as to those from other countries who were sent to Cameroun for instruction. He was effective in maintaining a cold chain for vaccine preservation and in convincing those in rural areas of the importance of this procedure. In addition, he established and maintained an effective and equitable vaccine distribution system.

When in the bush, Simon could be relied upon to totally manage

the team and to assure that vaccination sessions, which frequently bordered on the hectic, always went smoothly. He would and often did perform the job of each team member from registrar to crowd controller to vaccinator.

In addition to French and Pidgin, Simon spoke Ewondo, Bassa and several other tribal dialects and was always quite resourceful in attempting to communicate with those whose language we did not speak.

There are those who, after reading the above, might question the uniqueness of Simon's contributions and be inclined to dismiss them with the remark that that was what the man was being paid to do. In my opinion, Simon's daily performance far exceeded the bounds of the conventional work relationship. The dedication with which he worked, his steadfast manner, his desire to succeed and accomplish in the face of what at times appeared to be countless frustrations, served as an inspiration to those of us who worked with him, and without a doubt significantly, contributed to the eradication of smallpox in Cameroun.

"Zero" (From page 7)

After that monsoon season, the tide began to turn against smallpox in India.

"The real praise goes to the army of Indians — in excess of 100,000 people — who in one way or another participated directly in the smallpox program," said one CDC epidemiologist. "There was such intensity and dedication to the program. It was a joy to observe"

"People do what they think they can do. It was an impossible dream — but it was finally perceived as becoming possible — and that made it possible," said Dr. Foege.

Between 1974-76 29 different nationalities participated in the program. The Indian Government welcomed their assistance, for they considered smallpox eradication a global problem — not just a domestic problem."

As the countdown against smallpox neared its close, Bangladesh and Ethiopia became the last strongholds of the disease.

In 1975 Bangladesh was thought to have had its final case. However, house-to-house searching found cases of the disease in villages of Bhola, a remote island in the Ganges Delta.

Refugees returning to Bangladesh from India, following the war between East and West Pakistan, brought smallpox into the country again. Superimposed upon a cumbersome national health superstructure, this situation made the second eradication project more complicated.

The Bangladesh campaign suffered from the floods of 1974, too. "Those floods caused much of the problem," said Dr. Stanley Foster, team leader of the WHO effort in Bangladesh. "They forced many people, including smallpox patients, to move from one area to another. The people traveled to the food-distribution centers and these places often became the smallpox-distribution centers."

"Our first efforts were to improve surveillance and reporting systems," said Dr. Stanley I. Music, who served in Bangladesh from 1973-1975.

Working through the existing Bengali health structure, the WHO team (See page 11)

What about Future For Variola Virus?

Reprinted from *New England Journal of Medicine*

Even before the last case of naturally occurring smallpox was recorded in Merka Town, Somalia, in October, 1977, appeals were made in the scientific and popular news media for "total" eradication of the smallpox virus, including the destruction of all strains being kept in laboratory freezers throughout the world. Such strains were perceived to be the only remaining source of virus and the last deterrent to eradication of the disease, which for centuries had caused disfigurement and death. These concerns were heightened by the unfortunate events in Birmingham, England, in August, 1978. Two persons became ill, one fatally, apparently the result of a laboratory-associated smallpox infection. The events in Birmingham clearly illustrated the danger of working with smallpox virus in inadequately equipped facilities. However, they also reinforced the experience of the last decade showing that smallpox outbreaks can be quickly contained if an accident occurs.

The World Health Organization (WHO) very early recognized the potential danger of laboratory-associated outbreaks and several years ago began a campaign of persuasion to reduce the number of laboratories retaining the virus. In 1976, 76 laboratories were known to have stocks of smallpox viruses. In January, 1979, the number of laboratories with smallpox virus was nine. By 1980, the WHO expects the number to be four or less. Three laboratories are to be designated WHO Collaborating Centers for Poxvirus Research: St. Mary's Hospital, London; Research Institute of Viral Preparations, Moscow; and the Center for Disease Control (CDC) Atlanta.

WHO safety standards for smallpox are high. For approval, such laboratories must meet a long list of requirements and undergo inspections by an international team. At present, only three laboratories — St. Mary's, the Institute für Schiffs und Tropenkrankheiten in Hamburg and CDC — meet these standards. Only one of them, CDC, is actually working with smallpox virus.

The strict WHO requirements for laboratory containment reduce the risk of accidental infection to very low levels, but the questions must still be asked, "Why take any risk? What is the need to undertake experiments with smallpox viruses now that the disease is eradicated?"

We believe the disease is gone, but the search for the virus continues. During the last 12 months, CDC's smallpox laboratory performed diagnostic tests on nearly 4000 specimens in suspected cases of smallpox, and the

demand for diagnostic tests is increasing. During the month of January, 1979, the laboratory received over 450 specimens from 13 African countries, mostly as a result of the WHO certification program, which includes a \$1,000 reward for a confirmed case of smallpox. To be certified as smallpox free, each country must have been free of disease for at least two years, as determined by extensive surveillance designed to track down all exanthems that clinically resemble smallpox. Fortunately, none of the specimens since October, 1977, have contained smallpox virus. Most specimens were from patients with chickenpox with unusual clinical manifestations. Other cases were herpes simplex infection, vaccinia, scabies and skin diseases of unknown cause. Each specimen, however, must be considered to contain smallpox virus until laboratory tests prove otherwise. In some cases a valid laboratory test requires smallpox virus as a control.

The WHO will convene a group of experts this year to evaluate the need to retain smallpox viruses once global smallpox eradication has been certified. Many questions still remain. For example, some of the suspected cases of smallpox over the past few years have been shown to be caused by pox viruses other than smallpox. Differentiation of these viruses from smallpox requires critical comparison. Within the last two months, two cases were diagnosed in the CDC laboratory as being monkey pox, a disease that in man is clinically indistinguishable from smallpox. The virus was first isolated in 1958 from captive monkeys, but has never been isolated in the wild.

Monkey pox was first recognized as a human disease in Zaire in 1970, nine months after the last case of smallpox had occurred in that region. Since then, 37 cases have been identified in six African countries: Zaire, Liberia, Nigeria, Ivory Coast, Benin and Sierra Leone. It is possible that other cases of monkey pox go undetected in the remote rain-forest regions, but the reporting of 37 isolated cases of rash disease in West and Central Africa provides reassurance that the surveillance system would detect outbreaks if smallpox still existed. Most of the cases of monkey pox have been in children. Five persons have died, the mortality rate being not unlike that of smallpox in West and Central Africa. There is little evidence of secondary spread among close contacts, and no evidence of tertiary spread.

There is much about the pox viruses, smallpox-like viruses in particular, that we still do not understand. We have yet to determine the ecology of monkey-pox virus. Could monkey pox be a progenitor of epidemic smallpox in human beings?

Also unresolved is the origin of white-pox virus, a virus biologically indistinguishable from smallpox virus. Since 1964, six viruses designated as white pox have been isolated from two captive cynomolgus monkeys, a chimpanzee, a sala monkey and two rodents captured in areas where cases of human infection with monkey pox have been discovered. The origin of this virus is puzzling. Is it of animal or human origin? Several viruses from nonprimates, such as camel-pox and gerbil-pox viruses, are biologically difficult to distinguish from smallpox. There are also reports of human case of buffalo-pox. How closely related are these viruses to human strains of smallpox? How likely are they to be transmitted to human beings? Could these pox viruses fill the ecologic niche vacated by smallpox virus? Answers to these and other questions require comparative studies with smallpox strains.

The extent of activity of some pox viruses has become apparent only after elimination of smallpox virus as a source of human disease. Newer pox

(See page 16)

A Santhali Vaccinator by Dr. James Nakano

A 21-year-old native of Chhotanagpur, Bihar, India, may be remembered as the last of many health workers in history to contract occupation-related variola major while fighting an epidemic of smallpox. He deserves a special place in the history of mankind's effort to conquer the terrible disease.

In 1974, the young man was admitted to the Tata Main Hospital in Jamshedpur with fever and a smallpox-like rash.

For the previous three months he had been in daily and intimate contact with smallpox patients as he located them, vaccinated them, and assisted in the Chhotanagpur Smallpox Eradication programme.

His own protection should have been complete. He had been vaccinated as an infant, revaccinated one week before becoming a vaccinator, and twice more during his three months in the smallpox program. It was not uncommon for vaccinators to administer vaccine to themselves in front of villagers to allay fears of those about to be given vaccine. His most recent vaccination—given for "demonstration"—was 13 days before smallpox lesions appeared on his left arm.

The vaccinator's case was unusual. First, because smallpox vaccination is one of the most effective of all immunizations. It provides nearly complete protection to all who have been successfully vaccinated. Second, because following

an initial appearance of lesions, and a near recovery, a second crop of lesions appeared, instigating a second and worse appearance of the rash.

Some four months after his initial bout with smallpox, he was admitted to the hospital with serum hepatitis. On the fourth day after his admission, the patient died of liver failure.

Epidemiologic studies and laboratory work on the young man's case were done at CDC. The course of his illness seems to suggest a constitutional abnormality in his immune system.

He was apparently able to respond to vaccine by antibody production, but did not retain "immunologic memory" and treated each subsequent vaccination as a new challenge.

The vaccinator worked in infected villages and probably had an unusually intense exposure to smallpox virus. It is possible that the vaccination site of the young vaccinator became contaminated by physical contact with a case of smallpox. It is also possible that the vaccination needle itself was contaminated with variola, and the result was variolation followed by systemic smallpox.

Whatever the answer, it is clear that the young vaccinator was one of many devoted health workers who risked infection in order to pave the way for a smallpox-free world.



REWARD IN HAND, this girl reported a verified case of smallpox.

"Zero" (From page 9)

established a system of weekly smallpox reports from "thanas," the basic administrative unit in Bangladesh. A report was expected even in the absence of smallpox. It also incorporated for the first time the concept of an "outbreak" in Bengali reporting.

In addition to improving an existing passive reporting system, the team inaugurated an aggressive, active system to search for smallpox. The search was conducted by Bengali health workers.

"Some of our Bengali health

workers modified the surveillance systems themselves," said Dr. Music. "Their active information gathering was particularly effective in their own districts."

In 1975 CDC epidemiologists Jerry Wheeler and Pat McConnon had their first experience with urban smallpox when they saw between 60 and 70 people with the disease in hospital wards in Dacca.

In the field, they covered up to 30 to 40 outbreaks a week, vaccinating people and supplying money for food. Guards were posted to keep track of contacts and all people were vaccinated within a half-mile radius of the outbreaks.

In 1971 Ethiopia became the last nation to join the WHO campaign against smallpox. In spite of civil war, difficult mountain terrain, poor roads, rain six months of each year, over 70 languages and 200 spoken dialects, the smallpox program made good headway.

Ethiopia, too, repeated the story of dedication and perseverance that had become the trademark of the global effort. When two smallpox cases were found in southwest Ethiopia, a runner ran two days during the wet season to get the message cabled to Addis Ababa. A surveillance officer, who then visited the area, had to walk for 15 days to reach his destination. He covered the 300-mile area in two weeks.

Dr. David J. Sencer, former Director of CDC, played a major role in committing CDC to the smallpox eradication campaign. In a 1976 interview for "War on Hunger," a publication of the Agency for International Development, he said of the program:

"Anyone who has had an opportunity to participate in the smallpox eradication program will never forget the thrill of the achievement of eradication — to see that people can work together — all colors, all religions, and all political beliefs — to bring about the complete destruction of a disease. It is a very thrilling thing to have been a part of this campaign. I don't think that anyone who has had anything to do with the program will ever forget it."

IN THE FIELD--Smallpox Program Photos



REQUIRED BOOSTER for Dr. J.D. Millar in Bihar State, India



CALLING DACCA by radio from field operations in Bangladesh is Dr. Stan Mu



IN EARLY DAYS (1966), Mali's Minister of Health, Dr. Somine Dolo (3rd from left) and Dr. Cheick Sow, director of endemic diseases service visit CDC to confer with Dr. D.A. Henderson (left), director of Smallpox Eradication Program, and Dr. David Sencer, CDC director.



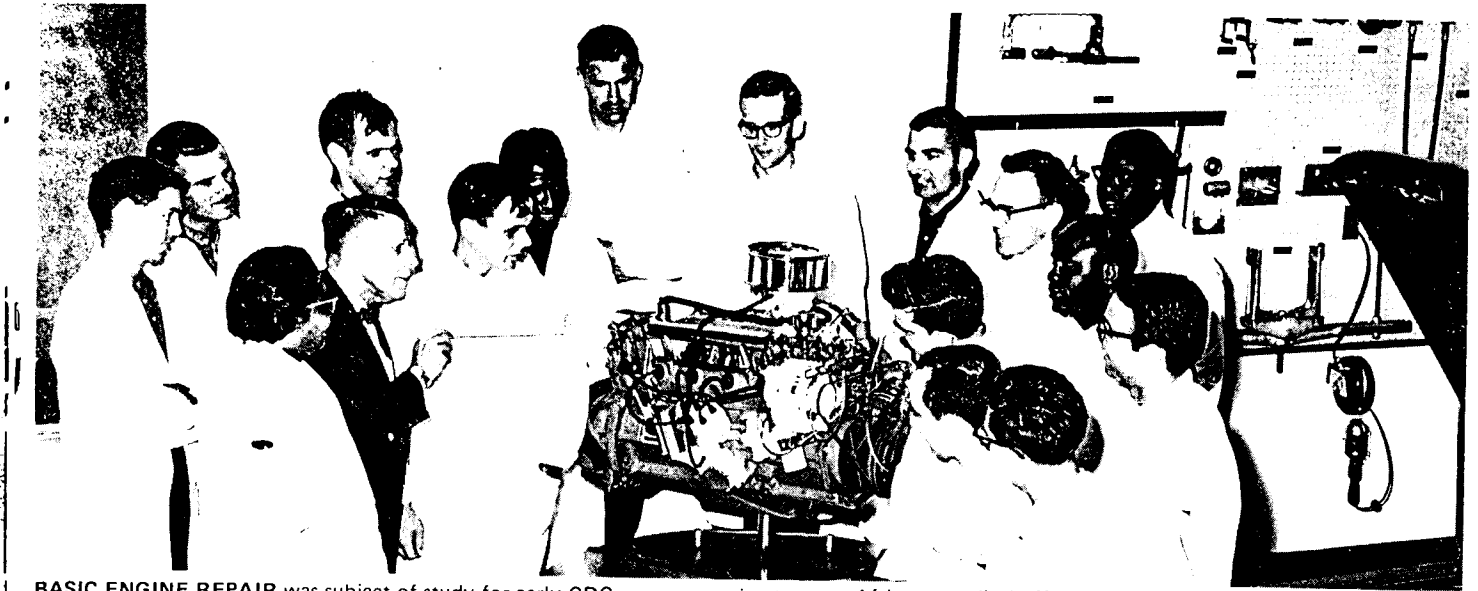
CAMEL RIDER Jay Friedman in Timbuktu.



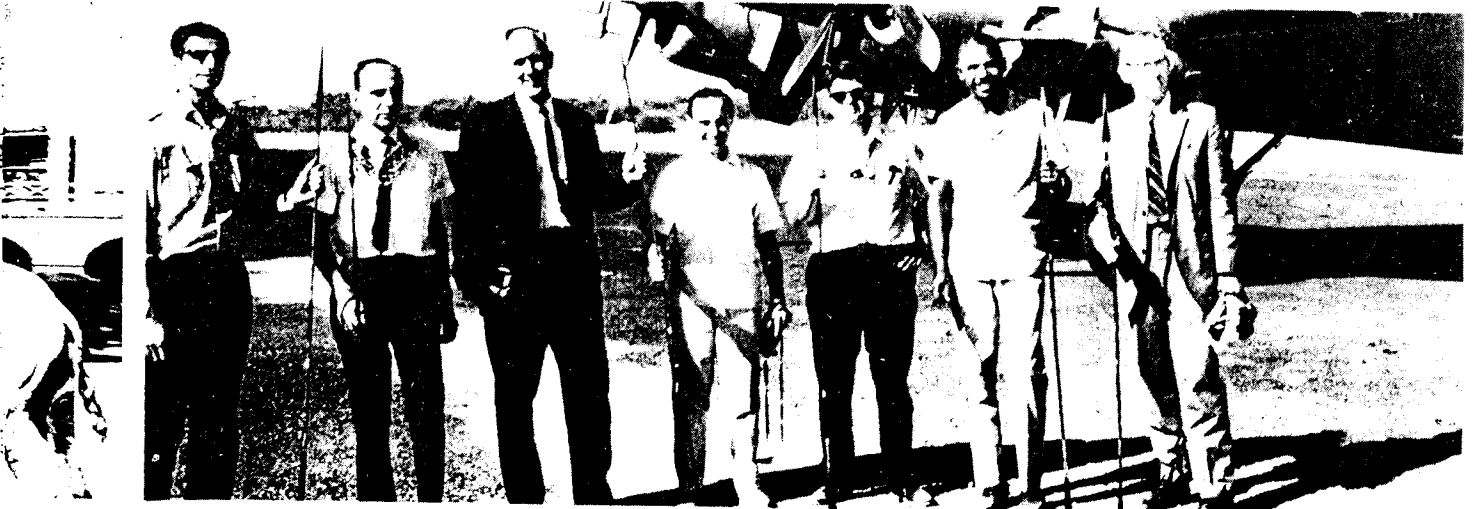
READY FOR ACTION - vaccination team in Bangladesh



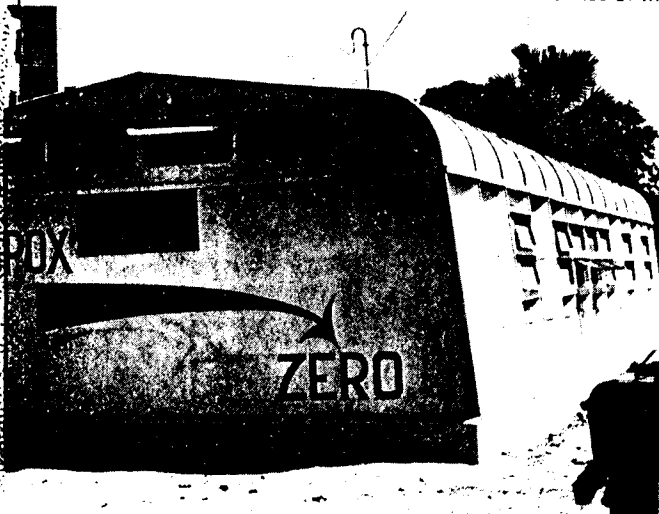
SMALLI



BASIC ENGINE REPAIR was subject of study for early CDC group preparing to go to Africa as medical officers and operations officers.



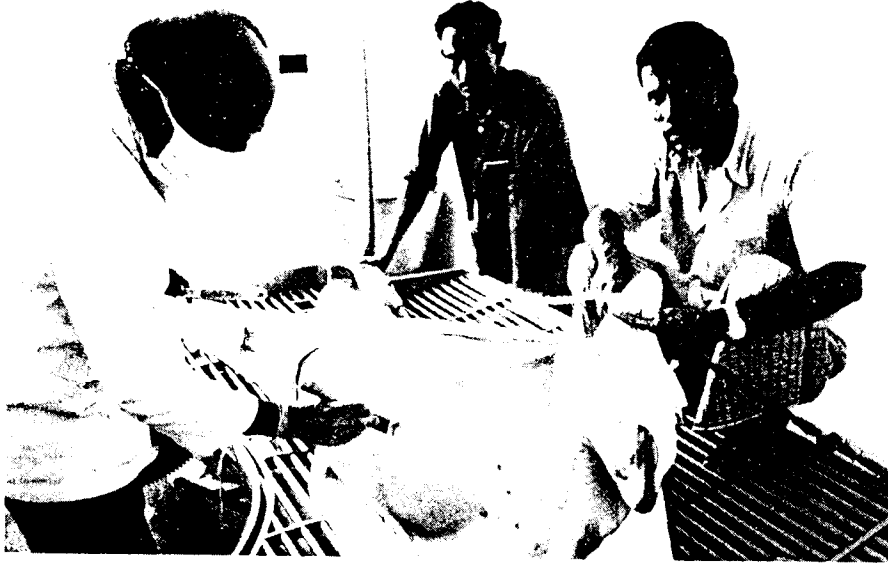
EVALUATION IN MALI — Jay Friedman, Dr. David Sencer, Surgeon General William H. Stewart, Dr. Pascal J. Imperato, Dr. J.D. Millar, Dr. George Lychott, and Ben Blood of the Office of International Health.



HEADQUARTERS in Dacca, Bangladesh



BRAZILIAN GIRL vaccinated with early model, spring-operated jet injector by Bill Dial.



SCRAPING calf's skin to inoculate with vaccinia virus to produce vaccine. Bangladesh.

Community (From page 8)

The center gets a steady flow of specimens from suspect cases: blood samples that might show antibodies against smallpox, as well as bits of tissue that might harbor the virus itself.

Specialists are particularly concerned about three new samples from Somalia because one of their own men in that country said the patients looked like smallpox cases to him. The specimens were expected to arrive today.

More Diagnostic Work

Meanwhile, as the number of smallpox cases has diminished, the press of laboratory diagnostic work has increased.

"We have had to stop work on almost everything else," said Dr. James H. Nakano, head of the laboratory at the center that studies smallpox. In ordinary times, he said in a recent interview, the laboratory tested about 300 specimens a year to confirm or rule out cases of smallpox.

Since eradication of the disease has come close, the number has been rising steeply. Last year the laboratory tested about 3,000 specimens, so far this year almost 1,300. All of the 1978 specimens have been negative.

The increase in workload is easy to explain. In a real outbreak of smallpox it is hardly necessary to do virus tests on every victim. It is all too obvious

what the infection is. But when the virus nears extinction, every single suspect case must be tested, including many that may be only remote possibilities. The success of the whole venture depends on finding every smallpox victim.

More Time-Consuming

From the laboratory worker's viewpoint the work is more difficult and time-consuming when there is no smallpox virus to be found. In many cases it only takes minutes to recognize a real smallpox virus under the electron microscope, Dr. Nakano said, but there are other viruses in the pox group that look much like it. Each such sample has to be grown in fertilized eggs or tissue culture and often put through a whole battery of tests to prove that it is not smallpox virus but something else.

As the laboratory work seems to be writing the final paragraphs of the old story of smallpox, public health officers are taking steps to prevent any epilogue. The center has prepared a detailed plan, titled Comprehensive Action in a Smallpox Emergency, for dealing with any reappearance of the disease.

The plan took months to put together and fills a large loose-leaf notebook. Dr. Michael Lane, director of the center's Bureau of Smallpox Eradication, said that it had been sent to every state health department in the country.

Possibilities of Reappearance

Presumably the most likely emergency would be the accidental release of virus from a laboratory, but other possibilities, including terrorism have been considered.

There is no known "animal reservoir" of smallpox virus, although it is possible that one exists, where the disease could linger after the last human case is past. Monkey pox, caused by a closely related virus, has proved capable of infecting humans. But experts at the Center for Disease Control say it does not seem to pass readily from person to person the way smallpox does.

In addition to smallpox and monkey pox, the pox family includes vaccinia-virus, from which smallpox vaccine is made, whitepox, cowpox, orf, milker's nodule, tanapox and the virus of molluscum contagium. Each causes a characteristic infection in humans or animals, but none approaches smallpox as a menace.

Asked to Keep Vaccine

In view of the possibilities of new smallpox outbreaks, the World Health Organization, which has run the decade-long campaign to eradicate the disease, has asked nations to maintain stockpiles of vaccine.

Dr. Lane said the United States already had almost enough bulk vaccine stockpiled at Wyeth Laboratories facilities in Marrietta, Pa., to protect 200 million people. Kept at low temperature in a freezer room, the vaccine is believed to have an almost indefinite lifetime. In an emergency more vaccine could be prepared fairly quickly.

A year ago at least 17 laboratories throughout the world kept the smallpox virus. Since then the World Health Organization has persuaded many to destroy their specimens.

The objective, Dr. Lane said, is to have no more than four, perhaps only two, laboratories in the world as repositories for the virus. One will be at the Center for Disease Control, which has played a major role in the world eradication effort. Another will probably be in a laboratory in Moscow. If there are four, the remaining two will be in London and Tokyo.

Reasons for Preservation

Dr. Nakano and other experts say there are three reasons to preserve a virus that has nothing to offer humanity but death and disfigurement.

The first is that, if there is a future epidemic that appears similar to smallpox, doctors will need to know whether it is a reappearance of the old virus or the appearance of something else that has emerged to fill the old disease niche.

Public health reaction to the swine flu virus of 1976 might conceivably have been far different, for example, had samples of the old 1918 flu virus been available for comparison.

The second reason is research. Common as smallpox was, said Dr. Walter Dowdle, head of the center's division of virology, the virus was relatively little studied.

The scientific methods and tools necessary for such studies have only recently been developed. Furthermore the smallpox virus is large and complex as viruses go—it is 20 times the size of the polio virus and three times the size of the flu virus.

The third reason cited for preserving the smallpox virus is more philosophical and, in Dr. Nakano's words, "perhaps humanitarian."

Even though it has always been an enemy of man, the smallpox virus is part of the immense skein of life on earth. Now, through human efforts, it faces extinction. Dr. Nakano thinks that man should not push it through the final step to oblivion. It would make no more sense to do so, he suggested, than to eliminate every other deadly living thing.



CANADIAN BOY who traveled from Brazil to Canada through New York in 1962



TAUREG GIRL in Mali pauses for vaccination against smallpox.

U.S. Saved Dollars By "Pox" Demise

Prevention of human suffering and death is the most important measurement of the significance of smallpox eradication. But there are also economic benefits.

During the 12 years of the eradication campaign the United States provided \$27 million in assistance. This amount is saved in this country every three months because routine smallpox vaccination is no longer required.

The U.S. no longer requires proof of smallpox vaccination from arriving international travelers, thus allowing additional resources to be directed toward other health activities. With the removal of the need for smallpox vaccination, the U.S. now has no routine vaccination requirements for persons entering this country.

Savings in dollars or convenience are small in comparison to the prevention of human suffering and death. In 1966, millions of cases of smallpox occurred in the world. Death and disfigurement were common. Today, a disease which has plagued mankind throughout history is no longer a threat.

Abu Yusuf

by Dr. Stanley O. Foster

Abu Yusuf, a legendary leader of the Bangladesh smallpox field force, frequently, because of his excellence, drew the most difficult field assignments. Spending 25 or more days a month in the field, he often ended up walking 20 to 30 miles through mud and rice paddy to investigate a rumor or supervise a containment.

Abu Yusuf also had a warm sense of humor. One day we found ourselves supervising a group of workers deployed at Chittagong railway station, to detect smallpox importations coming from the heavily infected bastees of Dacca. Walking along the platform, I passed a mother and infant, the latter showing a fresh primary take. Feeling progress was being made, I moved on. At the end of the platform, I turned to see Yusuf bending over the young mother. She was in the first day of smallpox rash, the most infectious period, and I had missed her. We picked up the patient and carried her to our Landrover for the trip to Isolation.

As we drove on, Yusuf turned and suggested that we share the 250 Taka (\$20) reward for detecting the new smallpox outbreak.

1844 (From page 1)

smooth away prejudices than the best native vaccinator.

"Actuated by these views he divided the whole of the territories of the Presidency into four grand divisions, and to each of these divisions he appointed a European vaccinator, with an establishment of native vaccinators under him. The European vaccinator was exempted from all local control, civil, military, or medical, and was at liberty to carry on his operations in whatever part of his district he might think proper, reporting monthly, to the medical board at Bombay. The salary was liberal, so that the vaccinator could at any time take a rapid journey, and come suddenly on his native assistants to ascertain the fidelity of their reports, settle quarrels, etc. and, in addition to the duties of superintending the vaccination, the vaccinator was provided with a supply of medicines and ordered to give advice and medical assistance to any of the natives who might apply to him. He was also furnished with from six to eight peons, to assist himself and his native subordinates in collecting the inhabitants, transmitting orders, producing supplies, etc."

That program did not eradicate smallpox from India.

Dr. Gerald Wusang

by Dr. J. Michael Lane

During the smallpox eradication efforts in Indonesia, it was generally difficult to get local medical officials interested and actively involved in the work. They were usually content to let the vaccinators work without field supervision.

Dr. Gerald Wusang was a young physician working in Bantang, a remote part of the southern Celebes Island. Because of his Chinese ancestry, he was not able to obtain a prestigious urban post, and was living a life of intellectual exile as a rural government physician. He had done an excellent job of remodeling his clinic and house, and was providing excellent medical care in his community, but he had no background or interest in public health. Since there was no public accommodation in his jurisdiction, I was billeted in Dr. Wusang's house when I worked in the Bantang area. He had taught himself English by listening to Australia short-wave news-casts, and we were able to communicate.

I sent vaccination teams to several outbreaks of smallpox around Bantang, with detailed instructions about the need to remain during the night, to vaccinate villagers who were away during the day.

From previous experience in Indonesia and elsewhere in the Celebes, I doubted that the teams would actually remain during the night, although Dr. Wusang assured me they would do whatever he ordered. I invited him to visit some of the villages with me at night, and as expected, the teams were nowhere in sight. The villagers were surprised and delighted that we had arrived to complete the promised vaccinations.

The field visit, the obvious impact of smallpox on the villages, and the realization that the vaccinators were not as reliable as he had assumed, had a tremendous impact on Dr. Wusang. He became an overnight smallpox fanatic. He kept up his busy clinical work but took on an active role in the supervision of outbreak containment and case tracing and investigation. I

Future (From page 10)

viruses may yet be discovered. Since some of these viruses may have the potential to cause human disease, it is clear that we can no longer rely on currently used biologic methods for differentiating pox viruses. More sophisticated methods are both needed and possible. A major effort is under way at the CDC laboratory to construct a catalogue and map viral DNA by restriction endonuclease analyses of the dozens of strains of smallpox and related pox viruses. In addition, research is under way to define biochemically the antigenic nature of each strain. Attempts thus far to characterize pox viruses through biochemical studies of their DNA have been encouraging. Additional work is necessary with appropriate human and animal strains to develop a greater

understanding of their genetic relations and to provide a basis for better prediction of disease potential. For this purpose, the smallpox virus is required.

The greatest impediment to the total eradication of smallpox is not the remote chance that a virus might escape from one of the several tightly supervised WHO-approved laboratories but, rather, premature complacency and the failure to achieve a full understanding of the relation of smallpox virus to the rest of the pox-virus family. Sometime during the next few years DNA studies of the pox viruses will probably make it possible to establish a definitive diagnosis without direct use of the smallpox virus. That may be a more appropriate time to consider total destruction of all live smallpox-virus stocks.

—William H. Foege, M.D.

was shortly able to leave his area and move on to less well organized jurisdictions, and he maintained prompt and efficient work while I was away. Indeed, he independently rediscovered all of the basic cannons of smallpox epidemiology: the close and prolonged contact necessary for spread, the efficacy of vaccination during the incubation period, the ploys to be used in contact tracing etc. Dr. Wusang is in fact responsible for much of the smallpox eradication work in the southern Celebes, but because it was outside his usual duties, his role has never been recognized.

Dr. Kamarul Huda

by Dr. Stanley O. Foster

Dr. Kamarul Huda, Sub-Divisional Medical Officer of Health for Chittagong District in Bangladesh, became a colleague and friend during 1973, when for 1 week each month we would work together to improve smallpox outbreak case detection and control in his division. Initially administering from his desk, Dr. Huda learned to lead his teams in the field in outbreak investigation, training, and supervision. On Sunday, March 2, we reviewed on the phone the progress toward smallpox zero. He passed on a telegraphic report of smallpox from Sandwip, an off-shore island in the Bay of Bengal. He would leave at daybreak.

The following morning, the scheduled steamer failed to sail. Dr. Huda climbed on board an overloaded country boat for the dangerous trip across open water.

Approaching Sandwip the boat overturned and Dr. Huda drowned, leaving a wife and two young children.

Dr. Huda was honored by his colleagues with the words of the Bengali poet Rabindranath Tagore:

You brought a deathless life with you which you made gift at your death.

In his death and the collective efforts of colleagues, suffering and death for many has been prevented.

Smallpox Successes Changed U.S. Vaccination Policy, 1971

During the 1960's, several physicians in the United States and the United Kingdom questioned the need to continue routine smallpox vaccination, which causes a slight, but definite rash of severe side effects.

This became official Public Health Service policy on October 1, 1971, with the publication of new recommendations of the Advisory Committee on Immunization Practices (ACIP).

Noting that no documented case of smallpox had occurred in this country since 1949, the ACIP statement of 1971 declared:

"For most people in the United States, the probability of contracting smallpox is so small that the risk of complications from vaccination outweighs the benefits..."

Announcement of the PHS decision noted, as an example, that in 1968 there were nine deaths associated with routine smallpox vaccination in the United States.

This official recommendation, while influential, did not have the immediate effect of stopping widespread vaccination in this country. States and many local governments had legal requirements for smallpox vaccination. Said the ACIP:

"The policy of nonselective vaccination... began when smallpox was widespread and uncontrolled. Under

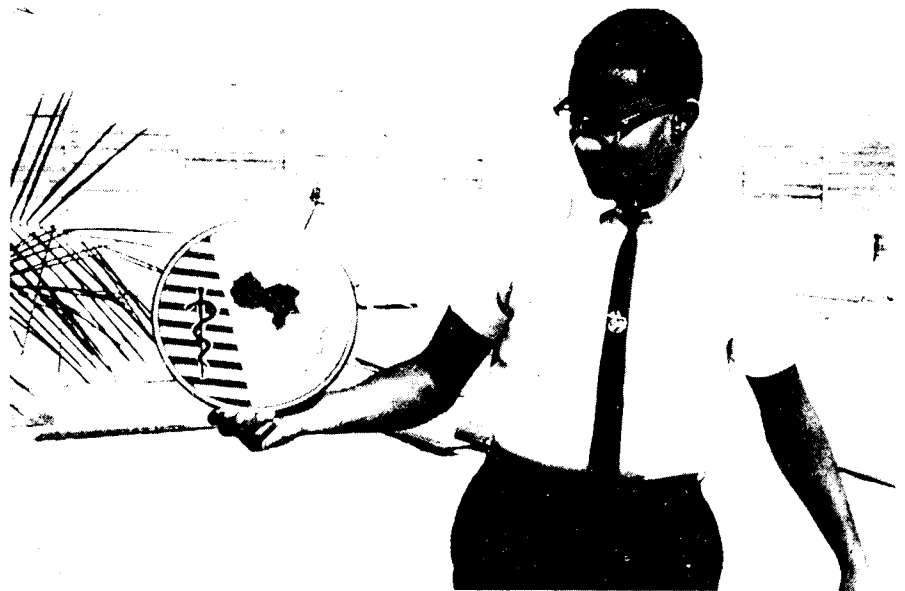
those conditions, it was a rational, necessary procedure, and legal regulations were passed to ensure vaccination of the public."

The announcement recognized that implementation of the recommendation would require legal changes in many areas. To help accomplish this, and to better understand the rationale for this decision, state and local health authorities were provided with detailed information on the current assessment of risks and benefits regarding smallpox vaccination in the United States.

Much of the information sent to states related to the risk of smallpox being imported into the U.S. The ACIP, in preparing its statement, concluded that the risk of importation of a case was unlikely.

However, to minimize concern about this remote possibility, the ACIP described the national smallpox surveillance system, as well as emergency procedures to be followed for management of contacts and preventing spread of the disease.

(See page 21)



SYMBOL of West African program displayed by Bernard Challinor.

POUR EVITER CETTE MALADIE



FAITES-VOUS VACCINER
CONTRE LA VARIOLE AU DISPENSAIRE



JOIN THE FIGHT
AGAINST
SMALL-POX
AND
MEASLES



BE

SHIGA CIKIN
YAKIN
KASHEN
AGANA
DA BAKON
DAURO



TAFI



MESSAGE FOR YOUR GOOD HEALTH

DAGA
CIWON AGANA



KAERE
YARANKA
DAGA
TA YI MUSU ALU



KO NOMBA
L'ONI
IJAFARA
L'EWU

GBOGUNTI
SONPONNA



LO KO
NOMBA
LONI

FREE NIGERIA
FROM
SMALLPOX AND MEASLES



BE VACCINATED
TODAY

BE VACCINATED THIS
NEW YEAR

AGG-NSI



SMALLPOX



BE VACCINATED NOW

POSTERS LIKE THESE played an important part in motivating people to get smallpox vaccinations in Africa and Asia.

REPUBLICQUE DE COTE D'IVOIRE
 MINISTERE DE LA SANTE PUBLIQUE
 ET DE LA POPULATION

**PLAN NATIONAL
 D'ERADICATION DE LA VARIOLE**

L'Action entreprise contre la variole se poursuit
 La Côte d'Ivoire déclarée Zone d'endémicité: les
 autorités Sanitaires sont habilitées à prescrire et pratiquer
 selon opportunité vaccinations et revaccinations:

**LA VACCINATION
 EST OBLIGATOIRE**

Les Employeurs des
 services publics et privés
 sont responsables
 de leurs personnels des me...

**TO AVOID
 SMALLPOX
 GET VACCINATED**

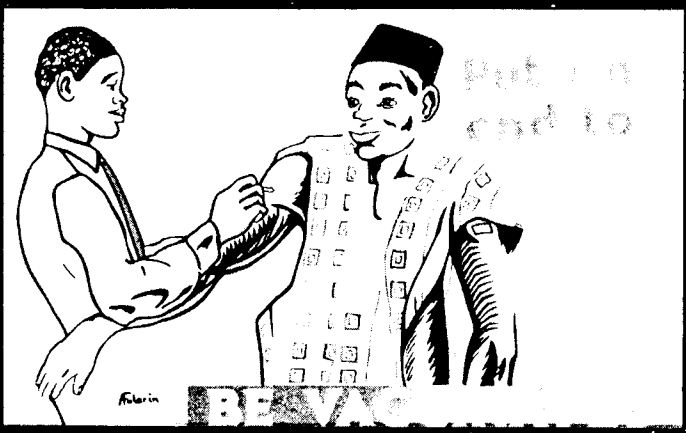
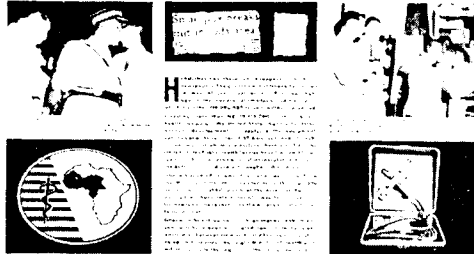
**PROTEGEZ-VOUS
 EN FAISANT VACCINER VOS ENFANTS
 UN ENFANT PROTEGE.**

**RENDEZ-VOUS
 AU CENTRE DE VACCINATION
 POUR VACCINER VOS ENFANTS
 CONTRE LA ROUGEOLE**



**RENDEZ-VOUS
 AU CENTRE DE VACCINATION
 POUR VACCINER VOS ENFANTS
 CONTRE LA ROUGEOLE**

**GHANA LAUNCHES DRIVE AGAINST SMALLPOX AND MEASLES
 AS A PART OF NEW 19-NATION WEST AFRICAN CAMPAIGN**



चैचक तें टीके की नई प्रणाली

सरल और सुरक्षित

तुरन्त ही टीका लीजिये
 और चैचक से
 छुटकारा पाइये।

**GHANA
 OKU A
 TATA
 ITUFU
 DI-N**

**KU KAI YAYANKI
 A YE MUSU LAMBA**

**JEKA KAYI
 TSAGA
 YAU**



BAKAYIBA

**CAMPAGNE
 CONTRE LA VARIOLE ET
 LA ROUGEOLE**



Wasa bi Kanga Sir Sen non lala
 mi Shi a dai a yi wa nyen
 / Kik-chi bapn yan
 mi Kham la y'Epim bi bapn yan.

Ayi din ni fili
 a Djussan Kadi
 Aka la dege: Ayi Tari la
 Shi Kasa!

VACCINEZ VOS ENFANTS
 Regardez cet enfant, il est heureux.
 Comme lui, faites vacciner
 votre premier ou deuxième.



**VACCINATED
 & MAKE IT A
 FREE YEAR**

Surveillance in Southern Sudan

by David C. Bassett

I arrived in Sudan in early 1973 to work with the Smallpox Eradication Program there. The last known smallpox case in Sudan had occurred in early December, 1972, in Southern Sudan. But it was thought very likely that smallpox still existed in Southern Sudan because in 1973 transportation and communications were very difficult, making large areas of the South almost inaccessible. Also, many people were still in hiding from the military hostilities which had ravaged the area for 17 years up to March 1, 1972. To be sure that there was no more smallpox in Southern Sudan, it would be necessary to plan and execute a special smallpox surveillance campaign.

There were no paved roads. Many of the existing roads were motorable for only 5, maximum six months of the year, November – April. Fuel for vehicles was in short supply. It was not possible to find food for purchase in the countryside, so food had to be collected at Juba, the regional headquarters. Yet even in Juba food supplies were difficult to obtain.

May to October, 1973 was spent planning a series of surveillance campaigns for the coming dry season. At the same time, supplies of fuel and food stuffs were being accumulated and stored, and arrangements were

being made to transfer personnel from other provinces, as necessary, to enable a maximum effort in campaign areas.

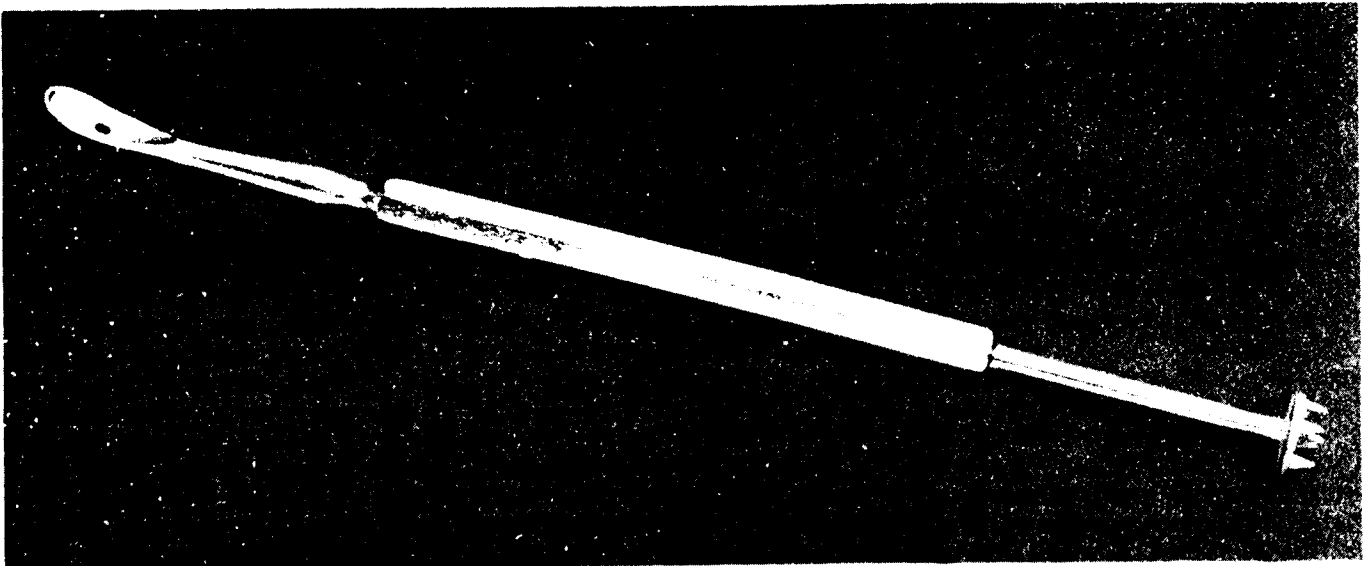
As WHO Advisor to the Sudan Smallpox Program, I helped with the planning of a series of 3 – 4 week surveillance campaigns. I knew I would not be able to personally participate in each of them, but I decided that I would participate in the first one, to take place in the eastern-most district of the Southern-most province. I could set the example, I reasoned, and then hope that it would be followed.

The first surveillance campaign was a field effort of 3 weeks that involved about 15 people travelling in convoy (three vehicles). My counterpart was a Sudanese with whom I had not previously worked, so we spent the first few days feeling each other out. With each passing day we formed a stronger bond of mutual respect. The 3-week campaign was completed without problems. No evidence of recent smallpox was found.

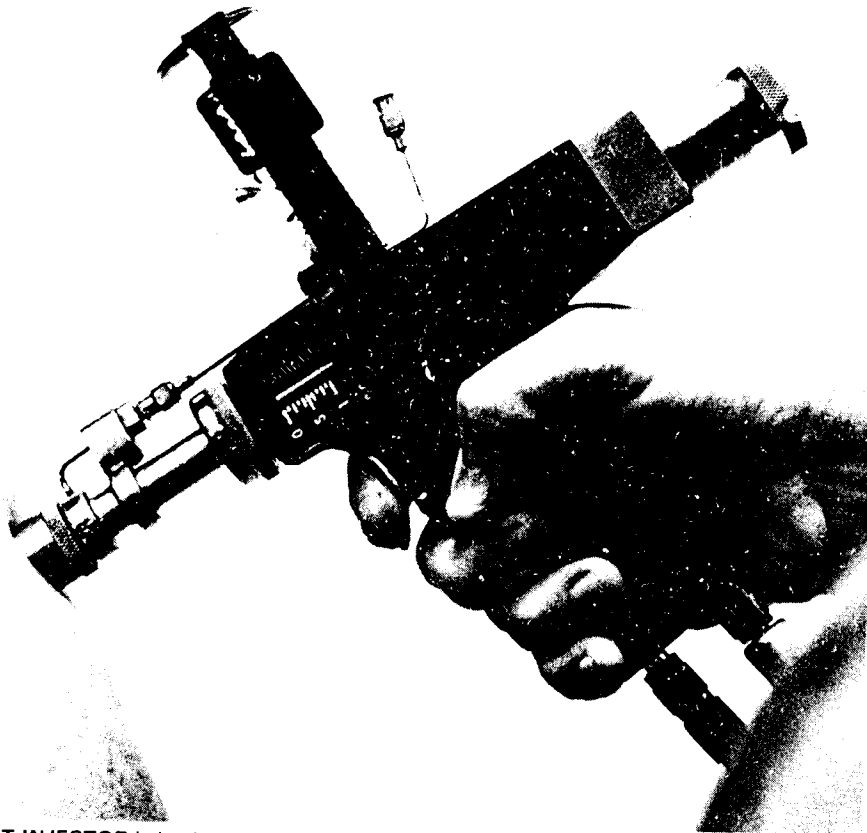
A second campaign was planned for the following month. As I would not be able to participate in this campaign, I placed my counterpart in charge and went over the strategy with him in great detail, listing the places to go, the people to visit, and the information to gather. I then left for Khartoum, hoping for the best.

At the end of the next month I received a cable from my counterpart saying that the second campaign was completed, that no fresh smallpox cases had been found, but that some old cases possibly occurring in April, 1973, had been found. Since April, 1973 cases would mean a previously unknown foci, I cabled back my congratulations on a job well done and asked my counterpart to wait for me in Juba so that we could go together to re-visit the site where the old cases were found.

The subsequent journey to the South and the visit to the old cases made it clear to me that smallpox surveillance in Sudan could proceed with a minimum of direct involvement by myself. The old cases had been found in an extremely remote mountainous area some 60 miles off the main road. It was clear to me that my counterpart and his colleagues had been following my instructions to the letter and that I did not need to worry that any thoroughness was being sacrificed because I was not there. The fact that the old cases found were probably infected in April 1972 rather than 1973, did not detract from this. My counterpart and his colleagues were proud of what they had done and I knew that the rest of the surveillance campaign in Southern Sudan was in good hands.



ROTARY LANCET formerly widely used.



JET INJECTOR helped make African program succeed.



BIFURCATED NEEDLE in use.

Technology (From page 8)

England. Vaccine produced remained potent for two years when stored at body temperature, so it seemed to meet the unusual needs of the smallpox eradication effort.

But during the early days of the eradication campaign, there were severe problems in supply and quality of freeze-dried vaccine. Only a small percentage of the freeze-dried vaccine in countries where smallpox was endemic met the potency and stability requirements of the World Health Organization.

Another critical problem was the lack of a central laboratory for testing vaccine. To meet this need, two major laboratories, in Canada and the Netherlands, agreed to serve as international vaccine reference centers.

In the early stages, most vaccine used was provided by Russia or the United States. Gradually, production of quality vaccine increased in the endemic countries. By 1970 all vaccine used met accepted international standards of potency and stability.

Policy (From page 17)

These procedures were described in detail in a manual entitled "Comprehensive Action in a Smallpox Emergency." It was written to assist the health official in each state (usually the State Epidemiologist) who would be responsible for taking appropriate action.

Implementation of the recommendations to halt routine vaccination moved smoothly, but some areas of the country continued to require smallpox vaccination for school entry beyond 1971. None require it today.

ACIP recommendations have been further modified since the 1971 announcement. The only persons recommended to receive smallpox vaccination today are the few laboratory workers likely to come in contact with the virus, and travelers to countries requiring vaccination as a condition of entry.

Despite widespread adoption of the recommendation to stop most smallpox vaccination, many people in the

(See page 22)

HISTORICAL VIGNETTES

- The first medical pamphlet published in North America was written by a minister over 300 years ago on the subject of smallpox.
- From 1617 to 1619 an outbreak of what was probably smallpox killed about 90 percent of the Indians on the Massachusetts coast making it easy for the pilgrims to land in 1620. Miles Standish wrote, "Smallpox was the blessing in disguise that gave our immigrant ancestors an opportunity to found the State."
- In 1730 seven percent of the residents of New York City died in a 3-month period of time from smallpox.
- Some of the earliest vaccine in this country was carried by Lewis and Clark. Thomas Jefferson, scientist, man of curiosity, obtained vaccine in 1801 and took it to Monticello to vaccinate his family and neighbors. Lewis and Clark were given the vaccine specifically to encourage its use among American Indians. Smallpox among the American tribes was more influential than the U.S. Army in neutralizing opposition.
- In 1716 Lady Mary Montagu, wife of the British ambassador to Turkey, saw variolations or inoculation in Turkey and described how 15 or so people would be taken at one time to be isolated in a farm house. They would then be inoculated simultaneously and kept in isolation for several weeks so that the mild smallpox which occurred in many of them would not spread to the community. She convinced the British royal family of the procedure's usefulness. The royal family in turn tested the procedure on prisoners and then on their own children. By the 1720's inoculation was an accepted technique for some practitioners in England.
- Cotton Mather, the distinguished third generation American minister in Boston, learned that slaves in the U.S. were using inoculation, a technique they had brought from Africa. In 1721 a ship docked in Boston introduced smallpox to the 11,000 residents of Boston. Within 6 months 6,000 had become ill. Cotton Mather began to preach the value of variolation, but



EMIR OF ZARIA receives vaccination in northern Nigeria. In center background is Dr. Deane Hutchins, who was medical officer for smallpox eradication program.

met with a hostile reception. Attempts were made to fire bomb his house and a storm of opposition developed.

- In 1776 the American colonial army lost Quebec, and consequently all of Canada, to the British. The British army, outnumbered two or three to one, were variolated. The American troops were not, and came down with smallpox.

In January 1777 as the result of the defeat at Quebec, Congress provided General Washington sanction to variolate members of the military.

- The Royal Houses of Europe and Asia were hosts to smallpox from age to age. In many ways history has been changed because of monarch's or

princes stricken in their prime. Among the royal victims are Prince Baltasar Carlos of Spain; Queen Ulrika Eleonora of Sweden; Queen Mary II of England; Louis XV of France and Joseph I of Austria. K'Ang-Hsi, emperor of China, is depicted on the cover of his autobiography with smallpox scars clearly visible.

Policy (From page 21)

U.S. still are vaccinated. Latest estimates indicate that more than four million doses of the vaccine were distributed in the U.S. in 1978.

But, for all practical purposes, smallpox vaccination in the U.S. has ended, thus ending risks and discomfort for millions.

REWARD - RECOMPENSE
\$1000

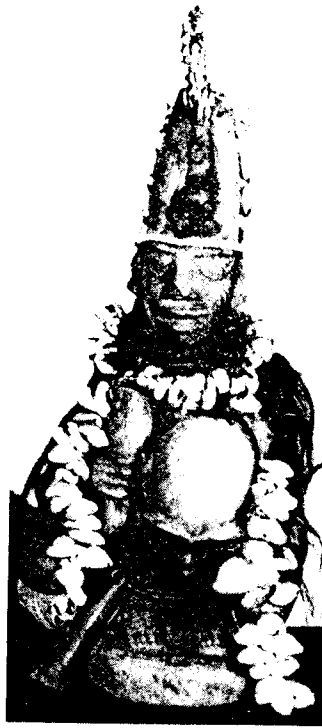
Smallpox Variole OC1A Viruela Smittkoppor

The World Health Organization offers US \$ 1000 to the first person reporting an active smallpox case resulting from human-to-human transmission and confirmed by laboratory tests. Valid until global eradication is certified.

L'Organisation mondiale de la Santé offre une récompense de US \$ 1000 à la première personne qui dépose une annonce officielle de transmission d'un être humain à un autre et confirmée en laboratoire. Cette offre est valable jusqu'à la certification de l'éradication mondiale.

الجزيرة Furuqa Ndur (1977)

REWARD POSTER has been widely used recently in search for any possible case.



SMALLPOX GOD with monkey skull,

Countries in which CDC Personnel Participated in Smallpox Investigation/Control Activities

- | | |
|----------------------|-------------------|
| EUROPE | Guinea |
| England | Sierra Leone |
| Sweden | Liberia |
| Yugoslavia | Ivory Coast |
| | Ghana |
| ASIA | Togo |
| Burma | Benin |
| India | Nigeria |
| Bangladesh | Cameroon |
| Nepal | Chad |
| Pakistan | CAR |
| Afghanistan | Gabon |
| Indonesia | Equatorial Guinea |
| | Mali |
| | Niger |
| LATIN AMERICA | Upper Volta |
| Brazil | Congo |
| | Zaire |
| AFRICA | Sudan |
| Mauritania | Somalia |
| Senegal | Ethiopia |
| Gambia | Djibouti |

NATIONS WITH ENDEMIC smallpox in 1966, before start of WHO eradication program. Brazil became focal point for program in Americas.



Smallpox Warriors Battle Other Diseases from CDC

The following list includes the names of those CDC staffers who worked abroad fighting smallpox. It also includes those who worked in the eradication program through Foreign Quarantine, and in the Smallpox Laboratory at CDC. Hundreds of others played vital support roles in the campaign and we regret that because of space limitations we have not included all of their names. Those listed gave credit to many more who stayed state-side to "make their jobs possible."

With a list of this size, it is likely that names which should have been included have not been. If omissions are called to our attention, we will include them in any future use of the list.

Adams, Vernon, M.D.	Farer, Laurence, M.D.	Kissee, Ben	Paz, Elizabeth
Adcock, David E.	Feld, Bernard	Kloth, Theodore I., M.D.	Perry, Samuel R.
Agle, Andrew N.	Ferrazano, Gabriel, M.D.	Koplan, Jeffrey P., M.D.	Peters, Bruce F., M.D.
Alexander, Charles	Fischman, Paul, M.D.		Pifer, John M., M.D.
Alfaro, August A.	Fitzgerald, Stephen A.	LaForce, F. Marc, M.D.	Pope, Randall S.
Allman, Kenneth	Flanders, Gerald P.	Landrigan, Phillip J., M.D.	Post, Clarence J.
Alter, Annabelle H.	Foege, William H., M.D.	Lane, J. Michael, M.D.	Pratt, David, M.D.
Andrews, John S., M.D.	Folland, David, M.D.	Langmuir, Alexander D., M.D.	Pust, Ronald E., M.D.
Appleton, Fred	Fontaine, Robert E., M.D.	Lantz, Samuel A.	
Arnold, Richard B., M.D.	Forney, David L.	LaPointe, Mark D.	Quinn, Michael J.
	Forrester, Willis R.	Larry, Daryl, M.D.	
Baldwin, Robert J.	Foster, Stanley O., M.D.	Larson, Edward	Raines, David
Barbour, Alan, M.D.	Francis, Donald P., M.D.	Lather, George	Ramirez, Robert
Barry, William	Freedman, George I.	Leggin, Phillip	Reiman, Sol
Bassett, David C.	Freemont, James M.	Lenz, Catherine E. Vaughn	Rich, James A.
Bentley, Jean C.	Friedman, Jay S.	Leonard, Thomas A.	Richardson, John H., M.D.
Berall, Jonathan, M.D.		Lessin, Phillip	Robbins, Gordon E.
Berg, George M., M.D.	Garcia, Luis A.	Leutzinger, Craig	Roberto, Ronald R., M.D.
Bernier, Roger H.	Garrett, Woodrow A.	Lewis, James O.	Romm, Frederick J., M.D.
Berry, Frank	Gelfand, Henry M., M.D.	Lichfield, Paul Lantz	Roots, Logan H., M.D.
Bingham, Patricia G.	Gibson, James, M.D.	Lichfield, Paul R.	Rosenberg, Mark L., M.D.
Bloeser, Carl H.	Giordano, Joseph F.	Lincoln, Burton J.	Rosenbloom, Arlan L., M.D.
Blumenthal, Daniel, M.D.	Godfrey, Harry R.	Loggins, Mary S.	Rosenblum, Bernard, M.D.
Bond, Paul A.	Goldsby, James B.	Loher, Bernard J.	Rothstein, Nathaniel
Bourke, Anthony T., M.D.	Goldstein, Joel A., M.D.	Long, Gary W., M.D.	Roy, Jeannel A.
Boyd, Barbara A.	Grazis, Peter A.	Lorenz, Rodney A., M.D.	Roy, Muriel T.
Boyd, Robert A.	Greenberg, Richard, M.D.	Lourie, Bernard, M.D.	Ruben, Frederick L., M.D.
Bradley, Martin R., M.D.	Greenley, John W.	Lythcott, George I., M.D.	
Brar, Mukhtiar	Griggs, Billy G.		Scally, Francis J.
Breman, Joel G., M.D.	Grigsby, Margaret E., M.D.	McBean, A. Marshall, M.D.	Scardaci, Anthony M.
Brink, Edward W., M.D.	Guinan, Mary, M.D.	McConnon, Patrick	Schade, Charles, M.D.
Brix, Jack	Gunter, David L.	McEanney, John P.	Sencer, David J., M.D.
Broske, Stuart P., M.D.	Gunter, Dupree	Mack, Thomas M.	Shoemaker, William D., Jr.
Brown, Denise R.	Guyer, Bernard, M.D.	Malberg, Donald R.	Silvernail, Carl
Brown, Larry K.		Marino, Frank A.	Smith, Edward W. P., M.D.
Brown, Robert	Helmholz, Robert C.	Martin, William E.	Smith, James
Bunn, Jack C., M.D.	Hemmert, Wynn, M.D.	Marty, Michael J.	Smither, Steve, M.D.
Burger, Ronald	Henderson, Donald A., M.D.	Masso, Anthony R.	Sparks, Larry
Burk, John R., M.D.	Henderson, Ralph H., M.D.	Meehan, Leo J.	Staebling, Norman W.
Burke, Ralph	Herrmann, Kenneth L., M.D.	Meichinger, David B., M.D.	Stapp, Joy H.
	Herron, Charles A., M.D.	Melewicz, Frank M., M.D.	Stettler, Harrison C., M.D.
Carvell, Delbert	Hess, James P.	Meschlevitz, Carlton, M.D.	Stiso, Frank
Challenor, Bernard D., M.D.	Hicks, James W.	Millar, J. Donald, M.D.	Stroh, George
Charter, Russell S.	Hill, Carl C.	Miller, David C., M.D.	
Claquin, Pierre, M.D.	Hogin, Gary	Miller, Donna L.	Tapia, Robert
Connell, Fred, M.D.	Hogelin, Gary	Miller, Joe	Teller, Benjamin E., M.D.
Conrad, Gary	Holloway, Brian P.	Miller, Richard	Thieme, Martha L.
Copeland, Wallace	Hopkins, Donald R., M.D.	Mitchell, William H.	Thomas, Elaine A.
Crankshaw, Richard L.	Horne, Thomas	Mize, James W.	Thompson, David M., M.D.
Crippen, Peter H.	Howard, Richard D.	Monath, Thomas P., M.D.	Thornton, James
Curtis, Gerald	Huber, Charles	Moore, Donald J., M.D.	Tulloch, Roger
	Huber, William	Moore, Joseph N.	
D'Agnese, John J.	Hudgins, Michael P., M.D.	Morgan, Kenneth H.	VanBuskirk, Arthur
D'Amanda, Christopher, M.D.	Hughes, John, M.D.	Morris, Leo	Vanderhook, Ray, M.D.
Davis, Constance, M.D.	Hull, Harry F.	Moser, Claude R., Jr.	VanPatten, Harold
Davis, Daniel	Hutchins, Deane L., M.D.	Mosley, James W., M.D.	Vastine, David, M.D.
Davis, Elmer		Murphy, Kevin	Veazey, James M., M.D.
Davis, Hillard	Imperato, Pascal J., M.D.	Musante, Edward	
DesPrez, William L.		Music, Stanley I., M.D.	
Deubner, David, M.D.	Jackson, Richard J., M.D.		Wade, Lloyd W.
DeWeese, Luther E.	James, William	Nakano, James H.	Waldman, Ronald
Dix, Dennis J.	Jenkins, Lesley M.	Neff, John M., M.D.	Wanner, Rudolf C., M.D.
Donoho, James E.	Johnson, Deane	Nelson, John W., Jr.	Watkins, Charles H.
Drake, Thomas	Jones, Clara J.	Nelson, William C., Jr.	Watson, William C., Jr.
Drescher, John J.	Jones, John	Nelson, William Q.	Weisfeld, Jason S., M.D.
Drotman, Peter, M.D.	Jones, T. Stephen, M.D.	Newberry, David M.	West, Gary
Duerden, Edward F.	Jones, Warren R.	Newport, Frank E.	West, James W.
	Jordan, Wilbert C., M.D.	Nichaman, Milton Z., M.D.	Wheeler, Jerry
Economidis, Thomas	Karzen, Jerome B.	Noble, John, Jr., M.D.	Whipple, David
Eddins, Donald L.	Kay, Dale E.	Noonan, Allan S., M.D.	White, William J., Jr.
Ellis, Robert J.	Keenlyside, Richard A.		Wildner, Michael, M.D.
Emerson, Robert	Kelly, John	O'Connor, Richard	Williams, Eugene
Evans, Harmon H.	Kimmel, Thomas R.	Olsen, Dennis G.	Wilson, John E.
Evans, Robert N.	King, Leland	Orenstein, Walter, M.D.	
Ewen, Neal H.	Kingma, Frederick S.	Osborne, Arthur, M.D.	Zyler, Laurence D.