

POLIO is a cruel disease that has disabled many people – especially children – over the last century or so. It is caused by a virus, and is passed from person to person via unwashed hands or contamination of food or water. In most cases the infection provokes only a mild illness, but in some cases the virus may invade the central nervous system, leading to muscle degeneration and paralysis. Its full scientific name is poliomyelitis, so named because of inflammation of the ‘grey matter’ of the spinal cord (in Greek, *polios* means ‘grey’ and *myelos* means ‘matter’). Polio is probably an ancient disease, but it was not until the end of the 19th century that outbreaks of polio attracted serious attention. The first vaccines were developed in the mid-20th century, and with mass immunization the incidence of polio around the world has fallen dramatically.

In the summer of 1916 in Brooklyn, New York City, a small child lay sick. She was gasping for air, struggling to take each breath. Her desperate parents had no idea what was wrong. Late that night, the local doctor was summoned. He held the child’s hand and felt her pulse. She was feverish, delirious and clearly in intense pain. She began to lose all feeling and movement in her little legs. She lay on her bed soaked in sweat – listless and apparently almost lifeless. The doctor arranged to take her to hospital. Her parents were distraught that she was being taken away. She was admitted as an emergency. She had all the signs and symptoms of poliomyelitis or, as it was then known, ‘infantile paralysis’, and she was one of thousands of cases in the world’s most serious recorded epidemic of polio in 1916–17 in New York.

INFANTILE PARALYSIS

‘Infantile paralysis’ in 1916 was a diagnosis without hope, without treatment and with no known cause. Many children died, others spent months in hospital. There was little to be done but to wait and watch. By 1917, nearly 9000 cases of infantile paralysis had been recorded in New York City. Some victims were left permanently paralyzed, and around 2400 people, mostly children, had died. Many of the survivors spent the rest of their (often short) lives in ‘callipers’ or braces.



Linking dirt with disease, this picture was intended to demonstrate how illnesses like polio spread: a girl hugs a stray cat picked up whilst feeding on rubbish.

The authorities dealt with the epidemic in ways that were reminiscent of reactions to bubonic plague in earlier centuries. Road blocks were imposed and vehicles with children under 16 years of age were not allowed to come into the city. Some of the wealthier families fled to the countryside, but many others who tried to escape the pestilential city were sent back. In the poorer areas of the city,

timeline

1400 bc An Egyptian stele shows a young priest with a shortened, deformed foot typical of polio. The disease may be as old as humankind, but there are very few early descriptions.

AD 1789 A British surgeon-apothecary, Michael Underwood (1736–1820), makes the first known clinical description of polio, calling it ‘debility of the lower extremities’.

1831–5 One of the earliest recorded outbreaks of polio occurs on the island of St Helena; small epidemics follow in England and the USA.

1840 Polio is recognized as a clinical entity by the German physician Jacob von Heine (1800–79). He names it ‘infantile spinal paralysis’.

1890s–early 1900s Further epidemics in Scandinavia and New England, USA.

1908–9 The Austrian biologist and physician Karl Landsteiner (1868–1943) shows that polio is contagious by injecting a monkey with an emulsion made from the spinal cord of a polio victim; he then successfully transfers the virus from that monkey to another.

1916 At New York City’s Rockefeller Institute for Medical Research, Sirron Flexner (1863–1946) describes polio germs that he and his colleagues have seen under a microscope as ‘innumerable bright dancing points, devoid of definite size and form’.

1916–17 The world’s most serious recorded epidemic occurs in the USA. In New York City alone over 9000 cases are reported, while nationwide there are more than 27,000 cases and 6000 deaths.

1921 Franklin D. Roosevelt (1882–1945) contracts what was thought to be polio.

1927–8 Philip Drinker (1894–1972) and Louis Shaw (1886–1940) at Harvard School of Public Health, Boston, USA, develop an airtight chamber that pushes air in and out of an immobilized polio patient’s lungs. In 1928, a young girl at Boston Children’s Hospital becomes the first to use the ‘iron lung’.

1920s–1950s Major epidemics of polio occur regularly in the USA and other industrialized countries.

1933 Elizabeth Kenny (1880–1952) opens her first clinic in Townsville, Australia, for the care of polio victims. Her methods include physical therapy and heat treatment.

1938 Franklin D. Roosevelt sets up the National Foundation for Infantile Paralysis – the first public-health organization in the USA to rely on the general public for funds. Its annual ‘March of Dimes’ fundraising drives are highly successful, raising an estimated \$630 million between 1938 and 1962.

(continued ...)

'polio houses' were quarantined, warning placards were posted and 'crippled' children were forcibly removed to isolation hospitals. Cats and dogs, as possible carriers, were abandoned or killed; public places were shut or avoided; immigrant families were shunned and blamed. The city reeked of disinfectant as officials battled to sanitize and contain the spread of this mysterious summer sickness.

DIRT, DISEASE AND THE DANGER OF THE HOUSEFLY

Across the USA, there were 27,000 cases of polio and over 6000 deaths between 1916 and 1917. Almost all were children under the age of five. Americans were gripped by fear, panic and, above all, hopelessness. It was a terrifying disease, one that struck young children and inflicted appalling suffering. Polio has probably

been around for centuries but, for reasons that remain obscure, it seems to have become a serious problem only in the last hundred or so years (see Polio Puzzles, page 166).

In 1916 no one knew how the disease spread. Was it through the air or through water and food? There was no shortage of theories, from both medical and lay people. Some blamed summer fruits, ice creams, candy, maggots in the colon, insects, raw sewage, garbage, dust, poisonous caterpillars, mouldy flour, contaminated milk bottles or even bananas infected by tarantula spiders. Others advised parents to avoid close contact with their children, believing the disease to be transmitted through sneezing, coughing, spitting and kissing.

'In one house I went into the only window was not only shut, but the cracks were stuffed with rags, so that the "disease" could not come in. You can imagine what the dark, dirty room was like; the babies had no clothes on, and were so wet and hot that they looked as if they had been dipped in oil, and the flies were sticking all over them ...'

A LETTER FROM A SOCIAL WORKER DURING THE 1916 NEW YORK EPIDEMIC, REPRINTED IN A NEW YORK NEWSPAPER

In the USA and Europe in the late 19th and early 20th centuries, polio was predominantly a disease of the summer months. Drawing parallels with cholera, typhoid and other 'filth diseases', doctors linked polio with dirty environments and unsanitary conditions, especially in hot, smelly summers. Initially, in the wake



of the New York epidemic, immigrant ghettos and slum areas were targeted as the likely source of the disease. But in the summer of 1916 it became clear that the epidemic, while striking hardest at the young, affected both rich and poor, long-time residents as well as recent immigrants.

A poor New York City tenement room from 1911. The source of the outbreak of polio in the city in 1916 was blamed initially on slum dwellings such as this one.

The association between dirt and disease was extended to the idea that maybe the ubiquitous housefly carried the germs of polio - from filth to food, from the 'dirty' immigrant quarters to the sparkling 'clean' houses of the leafy suburbs. Discoveries in the field of tropical medicine in the late 19th and early 20th centuries had

atimeline

1942 The Sister Kenny Institute is established and directed by Elizabeth Kenny in Minneapolis, Minnesota, USA.

1948-9 John Enders (1897-1985), Thomas Weller (b.1915) and Frederick Robbins (1916-2003) at the Children's Medical Center in Boston, Massachusetts, succeed in growing the polio virus in non-neurological human tissue in the laboratory, paving the way for the development of a vaccine.

1952 In Pittsburgh, Pennsylvania, USA, Jonas Salk (1914-95), supported by the National Foundation for Infantile Paralysis, tests his inactivated vaccine on volunteers, including himself, the laboratory staff, his wife and children.

1954 The Salk vaccine is tested on nearly 1.8 million schoolchildren in the USA.

1955 The Salk vaccine is licensed following the announcement of the success of the Salk trials. In the notorious 'Cutter Incident', however, 200,000 people are injected with 'Salk vaccine' prepared by the Cutter Laboratories in California. The 'vaccine' turns out to contain virulent, non-attenuated polio virus: 70,000 children are left paralyzed, and ten die. A storm of controversy follows in the USA.

1961-2 Following successful trials in the USSR and elsewhere, the attenuated vaccine developed by the American scientist Albert Sabin (1906-93) is widely taken up in the USA and throughout the Pan-American Health Organization. The Sabin vaccine largely replaces the Salk vaccine since it can be administered orally rather than by injection.

All subsequent cases are either imported or vaccine-related.

1979 The last cases in the USA of paralytic polio caused by endemic transmission of 'wild' polio virus.

1988 The Global Polio Eradication Initiative, spear-headed by governments, the World Health Organization (WHO), Rotary International, the US Centers for Disease Control and UNICEF, launches a campaign to eradicate polio by 2000 - one of the largest public health initiatives ever seen.

1994 The Americas are certified as 'polio free', followed by the western Pacific region in 2000 and the European region in 2002.

2003 The number of polio cases worldwide decreases from 350,000 in 1988 to under 700 in 2003.

2007 The WHO states that the world now has its best chance ever to eradicate polio, but it still remains endemic in a few hotspots in Nigeria, India, Pakistan and Afghanistan.

shown that mosquitoes, fleas, flies and lice could transmit diseases like malaria, yellow fever, plague, sleeping sickness and typhus. The housefly was everywhere, buzzing on the piles of horse dung in the streets of New York, swarming in the garbage cans, then alighting on babies or infecting food. Attacking the housefly

became a major preoccupation. Garbage bins were sealed, houses were screened, windows shut, fly-swatting contests were held, while posters and pamphlets featured an image of a giant housefly menacing the children of the city.

We now know that the housefly is capable of carrying over a hundred pathogens. Polio, however, is spread primarily through contaminated water, food or unwashed hands.

The polio enterovirus is ingested and passes

into the gut. It is shed in the faeces, and can then infect those with poor sanitary facilities or inadequate hygiene. This pathway of transmission is known as the faecal-oral route. A high proportion of the population infected with the virus get a mild fever or show no symptoms but can act as carriers (an observation that was first made in Sweden early in the 20th century). The 1916 campaign in New York, involving quarantine, cleansing and disinfecting, arose out of desperation and uncertainty, but in retrospect some measures were not far off the mark.

A FAMOUS VICTIM

In a minority of people, for reasons still not fully understood, the virus moves from the intestinal tract into the bloodstream and then invades the central nervous system (the brain and spinal cord) where it causes serious damage, leading to muscle weakness, paralysis and sometimes death. In the early decades of the 20th century, finding a way of helping those who survived 'infantile paralysis' was as problematic as understanding its cause. Some doctors recommended heavy

'We have a gospel to preach. We need to make America "polio conscious" to the end that the inexcusable case of positive neglect will be entirely eliminated.'

FRANKLIN DELANO ROOSEVELT, 1932

POLIO PUZZLES

A curious feature of polio is why paralysis occurs in only about 1 per cent of all those infected, while 85-90 per cent

have no symptoms at all, and the rest only a mild fever. This varying severity may depend on the virulence of the polio strain, genetic factors, or possibly excessive muscular activity while the disease is incubating or during its early onset.

Another puzzle is why, over the course of the first half of the 20th century, polio in the West became associated with increased prosperity and

cleanliness. A disease spread by the faecal-oral route that flourishes at a time of improved hygiene is something of an epidemiological paradox. It has been suggested that over the past two millennia infants and children were constantly exposed to the disease in areas of poor sanitation and, while developing a mild fever, they were able to build up life-long immunity. Only when general standards of hygiene and public health improved did the mild form of the disease cease to be a constant part of life so that, when it did strike, children and adolescents had little early exposure, and thus little or no immunity.

massaging and exercising affected limbs, while others suggested putting them into plaster casts or callipers, recommending long periods of immobility to prevent deformities. Various experimental therapies such as lumbar puncture and injections of anti-polio blood serum were tried out in hospitals. Home remedies and preventions included anything from 'earthworm oil' to bathing in ox blood.

Heart-rending images of children crippled by infantile paralysis became all too familiar, but when in the summer of 1921 a prominent member of a wealthy New York family was struck down with polio, it became clear that the disease could affect anyone, no matter how old or how privileged. The victim was Franklin Delano Roosevelt (1882-1945), a rising star in the Democratic Party, and later four-times president of the USA. Roosevelt, then aged 39, had been taking his summer vacation on the island of Campobello, off the coast of New Brunswick and Maine, when, on the night of 10 August 1921, he was suddenly struck by the disease.

Roosevelt survived, but for the rest of his life he battled with his pain and disabilities. In 1924 a visit to Warm Springs, Georgia, inspired him to organize major fund-raising events to transform the spa town into a hydrotherapy and rehabilitation centre for polio sufferers. He also began to put the needs of the disabled on the political agenda.

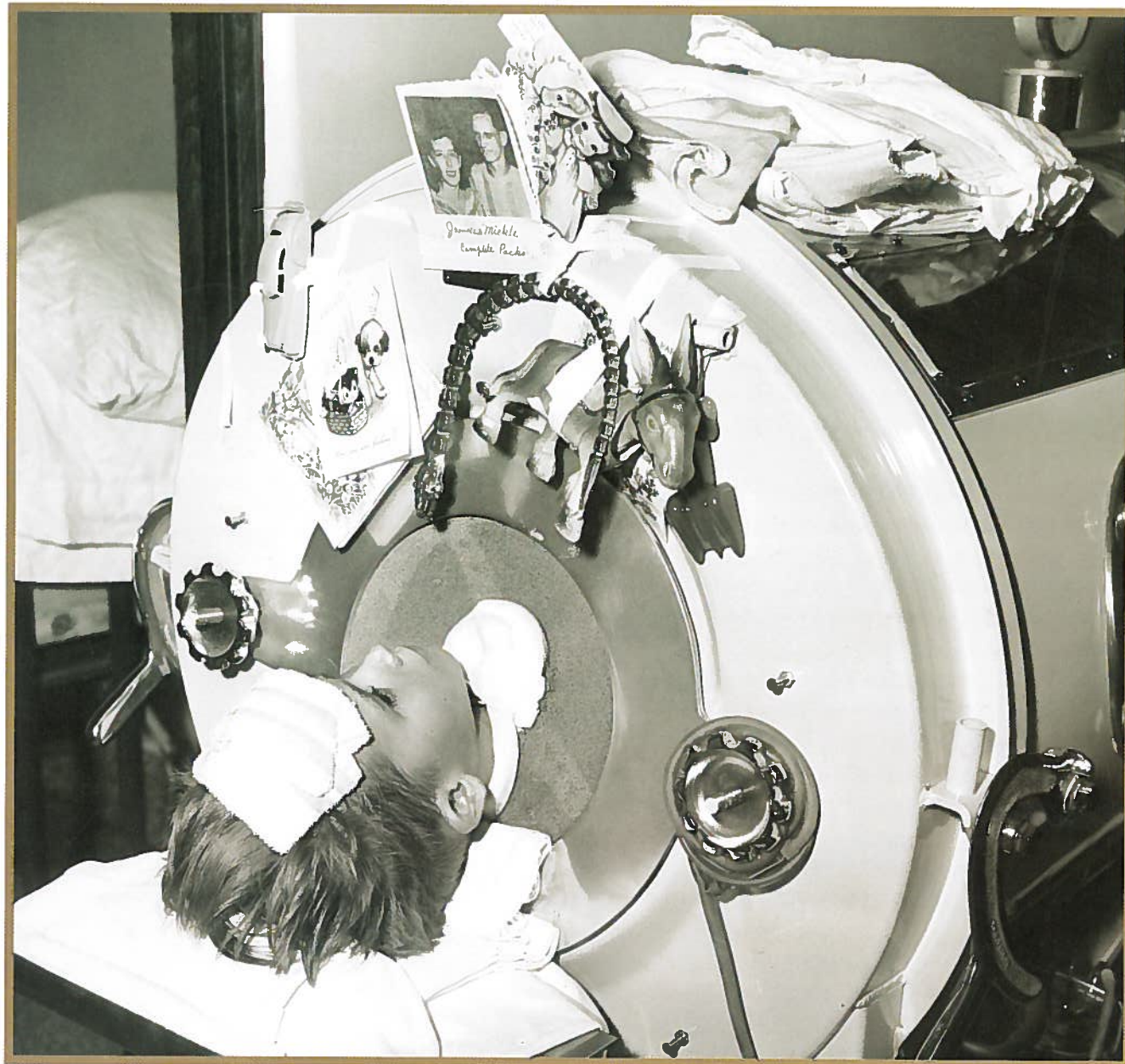
THE MARCH OF DIMES

As president of the United States from 1933 until his death in 1945, Roosevelt shouldered many burdens, first taking upon himself the task of mitigating the worst effects of the Great Depression, and then leading his country through the Second World War. He also had his own physical disability to cope with, but this was one thing he was determined to hide from the public: as far as we know, there are only two pictures of him in his wheelchair. While hiding his affliction, he remained committed to finding a way of helping his fellow sufferers.

What started out as Roosevelt's personal mission at Warm Springs became in 1938 the National Foundation for Infantile Paralysis, whose aim was to 'lead, direct, and unify the fight against every aspect of the killing and crippling infection of poliomyelitis'. Shortly after a radio appeal asking everyone to send their dimes (10 cents) to the president at the White House to fight polio, the sum of over a million dollars was collected. The annual 'March of Dimes' - the catch phrase for the polio crusade - raised \$630 million between 1938 and 1962. The Foundation did much to provide long-term care for sufferers, and also funded research and promoted awareness of the disease. Its propaganda film, *The Daily Battle*, features

Mary Kosloski, 1955 March of Dimes poster girl and polio sufferer, meets Randy Kerr, the US's first Polio Pioneer to receive the Salk vaccine the previous spring. Together, they represented the two aims of the March of Dimes - polio treatment and cure.





Because polio can paralyze the muscles used to breathe, some polio sufferers became dependent on a mechanical respirator, known as an iron lung, to assist with breathing.

a nearly invisible figure leaning on a crutch. This figure, known colloquially as 'The Crippler', stalks the land intoning the sinister but true words: 'And I'm especially fond of children'.

IRON LUNGS

The thermal baths at Warm Springs were a therapeutic treat for those with limited mobility. The most seriously affected polio survivors, whose respiratory muscles were paralyzed, experienced severe breathing and swallowing difficulties, and for them life hung in the balance. From the 1930s, artificial respiration was provided by the 'iron lung', a large, cumbersome and noisy device in which the patient was placed horizontally, and which pushed and pulled the chest muscles to make them work. For some patients, the iron lung provided temporary assistance, giving them

much needed time to recover their own respiratory muscle power. Others found themselves condemned to spend the rest of their lives in this fearsome and isolating machine. In Copenhagen, Denmark, in 1952, in one of the worst recorded polio epidemics in Europe, a shortage of iron lungs inspired the invention of an alternative method of artificial respiration. This involved making a surgical cut in the patient's trachea or windpipe (tracheotomy) and ventilating the patient using tubes and rubber bags. Some 1500 medical students assisted with the 'bagging method', devoting over 165,000 hours to saving the lives of many small children during the course of the epidemic.

SISTER KENNY

Iron lungs, tracheotomies, crutches, braces, splints and casts were all used with the best of intentions, albeit immobilizing patients and restricting the use of their paralyzed limbs. In the 1930s Sister Elizabeth Kenny (1880-1952), a colourful and imposing lady from the Australian outback, pioneered an alternative approach to try to get polio survivors back on their feet. The 'Kenny method', which combined physical and psychological techniques, involved hot packs, gentle 'retraining' of muscles, optimism and determination. For the lucky patients for whom this method worked it was close to a miracle, enabling them to reuse their weakened limbs with perhaps only the use of a walking stick, so giving them a new lease of life. Sister Kenny's methods were controversial but, until her death, she kept up her message that it was vital to 'remind the brain how to walk'.

A TALE OF TWO VACCINES

In the year of Sister Kenny's death in 1952, the USA was once more hit by a major outbreak of polio. Some 58,000 people were affected: 3000 died and another 21,000 were left paralyzed. Funds raised by Roosevelt's March of Dimes and the National Foundation for Infantile Paralysis had mostly been diverted to the care of survivors. Now the time was ripe to invest more into the search for a cure or vaccine. While antibiotics were revolutionizing the treatment of bacterial infections, attempts to find a remedy for viral diseases eluded the scientific community. There was, and perhaps never will be, a cure for polio. But in 1955 the USA celebrated the success of the first large-scale immunization of over 400,000 children with a safe and effective vaccine.

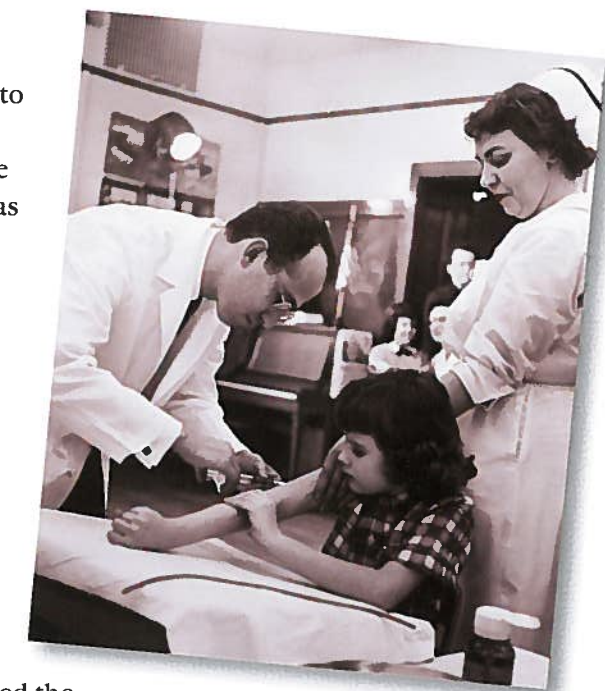
The man who had developed the vaccine, the American virologist Jonas Salk (1914-95), became a national hero overnight. His vaccine was based on an inactivated (i.e. dead) polio virus administered by injection and tested on nearly 1.8 million children (known as the 'Polio Pioneers') in a double-blind trial, with

A NARROW ESCAPE FOR THE RESPONAUTS

sometimes known by the term 'responauts'.

Patients who were confined to iron lungs to aid them with their breathing were

One patient vividly remembers a night in the early 1950s when suddenly the harsh hum of the iron lungs ceased. The night nurse had tripped over the cable that supplied power to the machines, and those encased within their iron lungs gasped for breath. The nurse quickly switched the power back on, and the 'swooshing and pulsing sounds' of the iron lungs returned.



Jonas Salk injects a child with his inactivated polio vaccine during field trials in Pittsburgh, 1954. Although this was superseded by Sabin's oral vaccine, an inactivated polio vaccine is still used in some countries.



American scientist Albert Sabin, seen here examining a young patient at an anti-polio hospital in 1967, developed the form of polio vaccine that was to become the accepted standard in most countries.

some receiving the vaccine, some a placebo and the rest acting as controls. Another American scientist, Albert Sabin (1906–93), went on to develop a live-attenuated vaccine, which was administered orally and offered some advantages over the Salk vaccine. Rivalry between supporters of one or the other vaccine flared up into one of the great feuds in medical history, with the players in the saga either at each others' throats or not on speaking terms.

Sabin conducted trials on a range of subjects, including his own family and prisoners in federal penitentiaries, followed by a large-scale immunization of several million people in the Soviet Union. Eventually, by the early 1960s, it was Sabin's oral vaccine that became the accepted standard in most countries. On 'Sabin Sundays', about 100 million Americans received the vaccine free of charge. A simple lump of sugar impregnated with the live polio virus – now usually given to infants – was subsequently instrumental in all but eliminating the disease in the Western world. There are still occasional outbreaks among unvaccinated groups, and rare cases of polio caused by the oral vaccine itself.

ON THE VERGE OF GLOBAL ERADICATION

While polio is no longer endemic in much of the Western world, it has remained until recently a serious problem in parts of Africa and Asia. In the late 1980s 'wild' polio was endemic in over 125 countries on five continents, paralyzing more than 1000 children every day. Its highest incidence was in the Indian subcontinent, and children crippled by polio begging on crutches on the streets of Calcutta, Delhi and other Indian cities were a common and haunting sight. Since then, there has been a major international effort to combat polio. In 1988, following the

success of smallpox eradication in 1979 (see page 136), the World Health Organization, inspired by Rotary International, passed a resolution to eradicate polio by the year 2000 so that '*no child will ever again know the crippling effects of polio*'. Private donors supplemented the funds given by national and international agencies. Some 2 billion children around the world have been immunized since the resolution was passed and, notwithstanding the difficulties and costs of administering the vaccine, the incidence of polio has declined dramatically.

Although the goal of eradication was not quite reached by the turn of the millennium, polio could now be on the verge of worldwide eradication. It remains endemic in only four countries – India, Nigeria, Pakistan and Afghanistan – and the annual number of new cases is down to hundreds rather than thousands. Total eradication of polio could be possible if the disease is eliminated from these last remaining hot spots, and we can only hope that the spectre of 'The Crippler' will no longer haunt the dreams of the world's children.

In an Indian village in 2003 a puppet show helps to educate children about polio, whilst behind them a poster about oral vaccine explains the preventative treatment to their parents.

POST-POLIO SYNDROME

For those who survived but were seriously affected by polio in the pre-

vaccination era, life has often been a struggle. Some polio survivors have been dependent on long-term care, but many faced the aftermath of this crippling disorder with resilience and strength. For them there was always the reassurance that, unlike diseases such as multiple sclerosis and muscular dystrophy, polio was not a progressive disorder.

In the late 1970s a disturbing and unexpected trend began to appear. A number of people who had suffered from polio in the past began to experience alarming symptoms of severe fatigue, muscle weakness and a range of debilitating polio-like symptoms. Some, who had been able to function with the aid of canes or crutches, now found their mobility severely limited. This is known as post-polio syndrome (PPS) or late effects of polio (LEP). Various theories have been proposed to explain PPS, though it is not believed to be related to persistence of the virus itself. The condition remains something of a mystery.

