= Polio vaccine =

Polio vaccines are vaccines used to prevent poliomyelitis (polio) . One type uses inactivated poliovirus and is given by injection (IPV) , while the other type uses weakened poliovirus and is given by mouth (OPV) . The World Health Organization recommends all children be vaccinated against polio . The two vaccines have eliminated polio from most of the world , and reduced the number of cases each year from an estimated 350 @,@ 000 in 1988 to 359 in 2014 .

The inactivated polio vaccines are very safe . Mild redness or pain may occur at the site of injection . Oral polio vaccines result in vaccine @-@ associated paralytic poliomyelitis in about three per million doses . Both are generally safe to give during pregnancy and in those who have HIV / AIDS but are otherwise well .

The first polio vaccine was the inactivated polio vaccine . It was developed by Jonas Salk and came into use in 1955 . The oral polio vaccine was developed by Albert Sabin and came into commercial use in 1961 . They are on the World Health Organization 's List of Essential Medicines , the most important medication needed in a basic health system . The wholesale cost in the developing world is about 0 @.@ 25 USD per dose for the oral form as of 2014 . In the United States it costs between 25 and 50 USD for the inactivated form .

= = Medical uses = =

Interruption of person @-@ to @-@ person transmission of the virus by vaccination is important in the global polio eradication , since there is no long term carrier state for poliovirus in individuals with normal immune function , polio viruses have no non @-@ primate reservoir in nature , and survival of the virus in the environment for an extended period of time appears to be remote .

= = = Inactivated = = =

When the current formulation of IPV is used , 90 % or more of individuals develop protective antibody to all three serotypes of polio virus after two doses of inactivated polio vaccine (IPV) , and at least 99 % are immune to polio virus following three doses . The duration of immunity induced by IPV is not known with certainty , although a complete series is thought to provide protection for many years .

= = = Attenuated = = =

OPV also proved to be superior in administration , eliminating the need for sterile syringes and making the vaccine more suitable for mass vaccination campaigns . OPV also provided longer lasting immunity than the Salk vaccine .

One dose of OPV produces immunity to all three poliovirus serotypes in approximately 50 % of recipients . Three doses of live @-@ attenuated OPV produce protective antibodies to all three poliovirus types in more than 95 % of recipients . OPV produces excellent immunity in the intestine , the primary site of wild poliovirus entry , which helps prevent infection with wild virus in areas where the virus is endemic . The live virus used in the vaccine is shed in the stool and can be spread to others within a community . The live virus also has stringent requirements for transport and storage , which are a problem in some hot or remote areas . As with other live @-@ virus vaccines , immunity initiated by OPV is probably lifelong .

The trivalent (against wild type 1 , 2 and 3) OPV has been used and nearly eradicated polio infection worldwide . Spearheaded by The Global Polio Eradication Initiative , 155 countries switched to use the bivalent (against wild type 1 and 3) between 17 April and 1 May 2016 . The bivalent OPV is at least 30 % more effective than the trivalent one .

= = = Schedule = = =

The World Health Organization recommends three or four doses starting at two months of age . It can be begun earlier but then additional doses are needed .

= = Side effects = =

The inactivated polio vaccines are very safe . Mild redness or pain may occur at the site of injection . Oral polio vaccine results in vaccine @-@ associated paralytic poliomyelitis in about three per million doses . They are generally safe to give during pregnancy and in those who have HIV / AIDS but are otherwise well .

= = = Vaccine @-@ induced polio = = =

A potential , but rare , adverse effect of the oral polio vaccine (OPV) is its known ability to recombine to a form that may cause neurological infection and cause paralysis . Clinical disease , including paralysis , caused by vaccine @-@ derived poliovirus (VDPV) is indistinguishable from that caused by wild polioviruses . This is believed to be a rare event , but outbreaks of vaccine @-@ associated paralytic poliomyelitis (VAPP) , caused by a circulating vaccine @-@ derived poliovirus (cVDPV) , have been reported , and tend to occur in areas of low coverage by OPV , presumably because the OPV is itself protective against the related outbreak strain .

= = = Contamination concerns = = =

In 1960 , it was determined that the rhesus monkey kidney cells used to prepare the poliovirus vaccines were infected with the SV40 virus (Simian Virus @-@ 40) . SV40 was also discovered in 1960 and is a naturally occurring virus that infects monkeys . In 1961 , SV40 was found to cause tumors in rodents . More recently , the virus was found in certain forms of cancer in humans , for instance brain and bone tumors , pleural and peritoneal mesothelioma , and some types of non @-@ Hodgkin 's lymphoma . However , it has not been determined that SV40 causes these cancers .

SV40 was found to be present in stocks of the injected form of the polio vaccine (IPV) in use between 1955 and 1963 . It is not found in the OPV form . Over 98 million Americans received one or more doses of polio vaccine between 1955 and 1963 when a proportion of vaccine was contaminated with SV40 ; it has been estimated that 10 ? 30 million Americans may have received a dose of vaccine contaminated with SV40 . Later analysis suggested that vaccines produced by the former Soviet bloc countries until 1980 , and used in the USSR , China , Japan , and several African countries , may have been contaminated ; meaning hundreds of millions more may have been exposed to SV40 .

In 1998 , the National Cancer Institute undertook a large study , using cancer case information from the Institute 's SEER database . The published findings from the study revealed that there was no increased incidence of cancer in persons who may have received vaccine containing SV40 . Another large study in Sweden examined cancer rates of 700 @,@ 000 individuals who had received potentially contaminated polio vaccine as late as 1957 ; the study again revealed no increased cancer incidence between persons who received polio vaccines containing SV40 and those who did not . The question of whether SV40 causes cancer in humans remains controversial however , and the development of improved assays for detection of SV40 in human tissues will be needed to resolve the controversy .

During the race to develop an oral polio vaccine several large scale human trials were undertaken . By 1958 , the National Institutes of Health had determined that OPV produced using the Sabin strains were the safest . Between 1957 and 1960 , however , Hilary Koprowski continued to administer his vaccine around the world . In Africa , the vaccines were administered to roughly one million people in the Belgian territories , now the Democratic Republic of the Congo , Rwanda and Burundi . The results of these human trials have been controversial , and unfounded accusations in the 1990s arose that the vaccine had created the conditions necessary for transmission of SIV from

chimpanzees to humans , causing HIV / AIDS . These hypotheses have , however , been conclusively refuted . By 2004 , cases of poliomyelitis in Africa had been reduced to just a small number of isolated regions in the western portion of the continent , with sporadic cases elsewhere . However , recent local opposition to vaccination campaigns has evolved , often relating to fears that the vaccine might induce sterility . The disease has since resurged in Nigeria and in several other African nations , which epidemiologists believe is due to refusals by certain local populations to allow their children to receive the polio vaccine .

= = Manufacture = =

= = = Inactivated = = =

The Salk vaccine , or inactivated poliovirus vaccine (IPV) , is based on three wild , virulent reference strains , Mahoney (type 1 poliovirus) , MEF @-@ 1 (type 2 poliovirus) , and Saukett (type 3 poliovirus) , grown in a type of monkey kidney tissue culture (Vero cell line) , which are then inactivated with formalin . The injected Salk vaccine confers IgG @-@ mediated immunity in the bloodstream , which prevents polio infection from progressing to viremia and protects the motor neurons , thus eliminating the risk of bulbar polio and post @-@ polio syndrome .

In the United States , vaccine is administered along with the diphtheria , tetanus , and acellular pertussis vaccines (DTaP) and a pediatric dose of hepatitis B vaccine . In the UK , IPV is combined with tetanus , diphtheria , pertussis , and Haemophilus influenzae type b vaccines .

= = = Attenuated = = =

Oral polio vaccine (OPV) is an attenuated vaccine , produced by the passage of the virus through non @-@ human cells at a sub @-@ physiological temperature , which produces spontaneous mutations in the viral genome . Oral polio vaccines were developed by several groups , one of which was led by Albert Sabin . Other groups , led by Hilary Koprowski and H.R. Cox , developed their own attenuated vaccine strains . In 1958 , the National Institutes of Health created a special committee on live polio vaccines . The various vaccines were carefully evaluated for their ability to induce immunity to polio , while retaining a low incidence of neuropathogenicity in monkeys . Large @-@ scale clinical trials performed in the Soviet Union in late 1950s to early 1960s by Mikhail Chumakov and his colleagues demonstrated safety and high efficacy of the vaccine . Based on these results , the Sabin strains were chosen for worldwide distribution . There are 57 nucleotide substitutions which distinguish the attenuated Sabin 1 strain from its virulent parent (the Mahoney serotype) , two nucleotide substitutions attenuate the Sabin 2 strain , and 10 substitutions are involved in attenuating the Sabin 3 strain . The primary attenuating factor common to all three Sabin vaccines is a mutation located in the virus 's internal ribosome entry site (IRES) which alters stem @-@ loop structures , and reduces the ability of poliovirus to translate its RNA template within the host cell . The attenuated poliovirus in the Sabin vaccine replicates very efficiently in the gut , the primary site of infection and replication , but is unable to replicate efficiently within nervous system tissue . In 1961 , type 1 and 2 monovalent oral poliovirus vaccine (MOPV) was licensed , and in 1962 , type 3 MOPV was licensed . In 1963 , trivalent OPV (TOPV) was licensed , and became the vaccine of choice in the United States and most other countries of the world , largely replacing the inactivated polio vaccine . A second wave of mass immunizations led to a further dramatic decline in the number of polio cases . Between 1962 and 1965 about 100 million Americans (roughly 56 % of the population at that time) received the Sabin vaccine . The result was a substantial reduction in the number of poliomyelitis cases , even from the much reduced levels following the introduction of the Salk vaccine .

OPV is usually provided in vials containing 10 ? 20 doses of vaccine . A single dose of oral polio vaccine (usually two drops) contains 1 @,@ 000 @,@ 000 infectious units of Sabin 1 (effective against PV1) , 100 @,@ 000 infectious units of the Sabin 2 strain , and 600 @,@ 000 infectious

units of Sabin 3 . The vaccine contains small traces of antibiotics ? neomycin and streptomycin ? but does not contain preservatives .

= = History = =

In generic sense , vaccination works by priming the immune system with an ' immunogen ' . Stimulating immune response , via use of an infectious agent , is known as immunization . The development of immunity to polio efficiently blocks person @-@ to @-@ person transmission of wild poliovirus , thereby protecting both individual vaccine recipients and the wider community .
The development of two polio vaccines led to the first modern mass inoculations . The last cases of paralytic poliomyelitis caused by endemic transmission of wild virus in the United States occurred in 1979 , with an outbreak among the Amish in several Midwest states .

= = = 1936 = = =

In 1936 , Maurice Brodie , a research assistant at New York University , attempted to produce a formaldehyde @-@ killed polio vaccine from ground @-@ up monkey spinal cords . His initial attempts were hampered by the difficulty of obtaining enough virus . Brodie first tested the vaccine on himself and several of his assistants . He then gave the vaccine to three thousand children . Many of these children developed allergic reactions , but none developed immunity to polio . Philadelphia pathologist John Kolmer also claimed to have developed a vaccine that same year , but it too produced no immunity and was blamed for causing cases of paralytic polio , nine of them fatal .

= = = 1948 = = =

A breakthrough came in 1948 when a research group headed by John Enders at the Children 's Hospital Boston successfully cultivated the poliovirus in human tissue in the laboratory . This group had recently successfully grown mumps in cell culture . In March 1948 Thomas H. Weller was attempting to grow varicella virus in embryonic lung tissue . He had inoculated the planned number of tubes when he noticed that there were a few unused tubes . He retrieved a sample of mouse brain infected with polio virus and added it to the remaining test tubes , on the off chance that the virus might grow . The varicella cultures failed to grow but the polio cultures were successful . This development greatly facilitated vaccine research and ultimately allowed for the development of vaccines against polio . Enders and his colleagues , Thomas H. Weller and Frederick C. Robbins , were recognized in 1954 for their labors with a Nobel Prize in Physiology or Medicine . Other important advances that led to the development of polio vaccines were : the identification of three poliovirus serotypes (Poliovirus type 1 ? PV1 , or Mahoney ; PV2 , Lansing ; and PV3 , Leon) ; the finding that prior to paralysis , the virus must be present in the blood ; and the demonstration that administration of antibodies in the form of gamma globulin protects against paralytic polio .

= = = 1952 ? 1953 = = =

The U.S. experienced an outbreak of 58 @,@ 000 and 35 @,@ 000 polio cases , respectively , up from a typical number of some 20 @,@ 000 a year . Amid this U.S. polio epidemic , millions of dollars were invested in finding and marketing a polio vaccine by commercial interests , including Lederle Laboratories in New York under the direction of H. R. Cox . Also working at Lederle was Polish @-@ born virologist and immunologist Hilary Koprowski , who claims to have created the first successful polio vaccine , in 1950 . His vaccine , however , being a live attenuated virus taken orally , was still in the research stage and would not be ready for use until five years after Jonas Salk 's polio vaccine (a dead @-@ virus injectable vaccine) had reached the market . Koprowski 's attenuated vaccine was prepared by successive passages through the brains of Swiss albino mice . By the seventh passage , the vaccine strains could no longer infect nervous tissue or cause

paralysis . After one to three further passages on rats , the vaccine was deemed safe for human use . On 27 February 1950 , Koprowski 's live , attenuated vaccine was tested for the first time on an 8 @-@ year @-@ old boy living at Letchworth Village , an institution for the physically and mentally disabled located in New York . After the child suffered no side effects , Koprowski enlarged his experiment to include 19 other children .

= = = Jonas Salk = = =

The first effective polio vaccine was developed in 1952 by Jonas Salk and a team at the University of Pittsburgh that included Julius Youngner , Byron Bennett , L. James Lewis , and Lorraine Friedman , but it required years of subsequent testing . To encourage patience , Salk went on CBS radio to report a successful test on a small group of adults and children on 26 March 1953 ; two days later the results were published in JAMA . Beginning 23 February 1954 , the vaccine was tested at Arsenal Elementary School and the Watson Home for Children in Pittsburgh , Pennsylvania . Salk 's vaccine was then used in a test called the Francis Field Trial , led by Thomas Francis ; the largest medical experiment in history . The test began with some 4 @,@ 000 children at Franklin Sherman Elementary School in McLean , Virginia , and would eventually involve 1 @.@ 8 million children , in 44 states from Maine to California . By the conclusion of the study , roughly 440 @,@ 000 received one or more injections of the vaccine , about 210 @,@ 000 children received a placebo , consisting of harmless culture media , and 1 @.@ 2 million children received no vaccination and served as a control group , who would then be observed to see if any contracted polio . The results of the field trial were announced 12 April 1955 (the tenth anniversary of the death of President Franklin D. Roosevelt , whose paralysis was generally believed to have been caused by polio) . The Salk vaccine had been 60 ? 70 % effective against PV1 (poliovirus type 1) , over 90 % effective against PV2 and PV3 , and 94 % effective against the development of bulbar polio . Soon after Salk 's vaccine was licensed in 1955 , children 's vaccination campaigns were launched . In the U.S , following a mass immunization campaign promoted by the March of Dimes , the annual number of polio cases fell from 35 @,@ 000 in 1953 to 5 @,@ 600 by 1957 . By 1961 only 161 cases were recorded in the United States .

= = = 1987 = = =

An enhanced @-@ potency IPV (inactivated polio vaccine) was licensed in the United States in November 1987 , and is currently the vaccine of choice in the United States . The first dose of polio vaccine is given shortly after birth , usually between 1 and 2 months of age , a second dose is given at 4 months of age . The timing of the third dose depends on the vaccine formulation but should be given between 6 and 18 months of age . A booster vaccination is given at 4 to 6 years of age , for a total of four doses at or before school entry . In some countries , a fifth vaccination is given during adolescence . Routine vaccination of adults (18 years of age and older) in developed countries is neither necessary nor recommended because most adults are already immune and have a very small risk of exposure to wild poliovirus in their home countries . In 2002 , a pentavalent (five @-@ component) combination vaccine (called Pediarix) containing IPV was approved for use in the United States .

= = = 1988 = = =

A global effort to eradicate polio , led by the World Health Organization , UNICEF , and The Rotary Foundation , began in 1988 and has relied largely on the oral polio vaccine developed by Albert Sabin and Mikhail Chumakov (Sabin @-@ Chumakov vaccine) .

= = = Post @-@ 1990 = = =

Polio was eliminated in the Americas by 1994 . The disease was officially eliminated in 36 Western

Pacific countries , including China and Australia in 2000 . Europe was declared polio @-@ free in 2002 . Since January 2011 , there were no reported cases of the disease in India , and hence in February 2012 , the country was taken off the WHO list of polio endemic countries . If there are no cases of polio in the country for two more years , it will be declared as a polio @-@ free country . As of 2016 , polio remains actively spreading in only two countries : Pakistan , and Afghanistan . Although poliovirus transmission has been interrupted in much of the world , transmission of wild poliovirus does continue and creates an ongoing risk for the importation of wild poliovirus into previously polio @-@ free regions . If importations of poliovirus occur , outbreaks of poliomyelitis may develop , especially in areas with low vaccination coverage and poor sanitation . As a result , high levels of vaccination coverage must be maintained . In November 2013 , the World Health Organization announced a polio outbreak in Syria . In response , the Armenian government put out a notice asking Syrian Armenians under age 15 to get the polio vaccine . As of 2014 , polio virus has spread out to ten countries mainly in Africa , Asia and the Middle East with Pakistan , Syria and Cameroon advising vaccinations to outbound travelers . In 2015 , the World Health Organization announced a deal with the Taliban to encourage them to distribute the vaccine in areas they control .

= = Society and culture = =

= = = Cost = = =

The wholesale cost is about 0 @.@ 25 USD per dose for the oral form as of 2014 . The inactivated vaccine is available to GAVI @-@ supported countries for as little as EUR 0 @.@ 75 per dose (approximately USD 1 @.@ 00 per dose at current exchange rates) in ten @-@ dose vials .
In the United States it costs between 25 and 50 USD for the inactivated form .

= = = Misconceptions = = =

A widespread misconception has arisen in Pakistan that polio vaccine contained Haram ingredients and could cause impotence and infertility in male children , leading some less @-@ educated parents not to have their children vaccinated . This belief is most prevalent in the Khyber Pakhtunkhwa province and the FATA region , where people are likely to be influenced by conservative teachings . There also have been attacks on polio vaccination teams . This is hampering international efforts to eradicate polio in Pakistan and globally since the virus can be carried by travelers .