C.

WORLD HEALTH ORGANIZATION
REGIONAL OFFICE FOR EUROPE

WELTGESUNDHEITSORGANISATION
REGIONALBÜRO FÜR EUROPA

ORGANISATION MONDIALE DE LA SANTÉ
BUREAU RÉGIONAL DE L'EUROPE

ВСЕМИРНАЯ ОРГАНИЗАЦИЯ ЗДРАВООХРАНЕНИЯ
ЕВРОПЕЙСКОЕ РЕГИОНАЛЬНОЕ БЮРО

Senior Level Seminar on EPI, CDD and ARI Control Programmes

Moscow, 25-28 May 1987

ICP/EPI 011/10
13 May 1987
2146G

ENGLISH ONLY

PROSPECTS FOR POLIO ERADICATION

by

Dr Alan R. Hinman, Director, Division of Immunization
Centre for Prevention Services, Centres for Disease Control
Atlanta, Georgia

PROSPECTS FOR POLIO ERADICATION

In the early 1950s poliomyelitis was a dreaded disease in the United States. Epidemic waves of increasing magnitude reached a peak in 1952, when more than 20,000 cases of paralytic disease were reported (Figure 1). Whole hospital wards throughout the country were devoted to treating those stricken with paralysis of the muscles of respiration. The introduction of inactivated poliovirus vaccine (IPV) in 1955 and its subsequent widespread use had a dramatic impact on the reported incidence of polio (Figure 2) although there was an upsurge in incidence in 1958 and 1959. When live attenuated oral poliovirus vaccine (OPV) was introduced in 1961, it rapidly replaced IPV as the vaccine used primarily in the United States (and in most of the rest of the world).

Use of poliovirus vaccines in the United States has resulted in the elimination of paralysis due to indigenously-acquired wild polioviruses. No such cases have been detected in this country since 1979. Similar successes have been achieved in many other industrialized countries, in most of them as a result of the use of OPV but in a few as a result of the use of IPV alone. Polio had previously been thought of as primarily a problem of developed countries. Classical theory suggested that in developing countries, infants would be exposed to polioviruses while still protected by maternally-derived antibodies and develop immunity without paralysis. As hygiene improved, early exposure would be less common and children would remain susceptible to a later age when it was thought paralysis might be more likely. Additionally, the accumulation of a group of susceptibles would make it possible for large-scale epidemics to occur. In the past 15 years, many studies have shown that polio is a world-wide problem and that the prevalence of lameness due to poliomyelitis in children is on the order of 5 cases per 1,000, similar to the incidence seen in developed countries. Paralytic polio in the developing world is primarily a problem of infants and very young children and, since exposure occurs at a very early age without allowing build-up of large groups of susceptibles, it occurs primarily as an endemic disease, rather than in epidemics. It is currently estimated that more than 250,000 cases of paralytic poliomyelitis occur each year in developing countries.

Given the terrible burden of polio in the world and the marked success of polio control and elimination in developed countries using current vaccines, interest has arisen in the possibility of eradicating polio. The 32 countries of the European Region of the World Health Organization (WHO) have established a target of elimination of indigenous poliomyelitis by the year 2000 and the 46 countries and territories of the American Region (acting through the Pan American Health Organization [PAHO]) have set a target of Regional Eradication by 1990. The remainder of this paper will consider the prospects for global eradication of poliomyelitis.

---

*Alan R. Hinman, M.D., Walter A. Orenstein, M.D., Edward W. Brink, M.D., and Peter A. Patriarca, M.D., Division of Immunization, Center for Prevention Services, Centers for Disease Control, Atlanta, Georgia 30333. Presented in part at the annual meeting of the American Epidemiological Society, Charleston, South Carolina, March 17, 1987.

Definitions

The Oxford English Dictionary defines eradication as "the action of pulling out by the roots, total destruction, extirpation. For purposes of discussion, consider a spectrum of disease incidence (Figure 3), with five levels depending on the degree of success of efforts taken against the disease. In the uncontrolled state, disease incidence is affected by the traditional triad of host, agent, and environment, and although evolutionary changes might lead to disappearance of the disease, there is no specific control action.

The application of specific measures to reduce the occurrence of a disease may lead to a situation of control in which continuing efforts leave the occurrence of the disease at a reduced, but presumably acceptable, level. From a state of control, elimination of a disease from a particular area can be achieved. In this situation, transmission has been interrupted and the disease no longer occurs on a continuing basis in the area. However, the threat of reintroduction of disease from endemic areas (with subsequent reestablishment of transmission) is so great that continuing control measures are required. This situation describes the present situation of poliomyelitis in the United States and the goal of the European Region of WHO. As the risk of reintroduction of disease is lowered through measures applied in other countries, regional eradication may be attained. In this case it is not necessary to pursue actively the control measures; surveillance and prompt response to importation are capable of maintaining the area free of disease. This is the goal of the American countries. The final leap, from regional eradication to global (or "true") eradication will only occur when all areas have achieved regional eradication. To date, only one disease - smallpox - has been eradicated from the earth. This is the longterm goal we recommend for poliomyelitis.

Certain factors favor eradication of poliomyelitis. These include the facts that infection results in lifelong immunity, there is no long-term carrier state, there is no non-human reservoir of infection, and effective vaccines are available. Factors not favoring eradication include the high rate of inapparent infection (making detection of the infectious agent more difficult), the absence of visible evidence of immunity (such as the scars of smallpox or vaccinia), and the fact that the vaccines are not perfectly effective. On balance, we believe that the negative factors are not insurmountable and that eradication can be achieved by a program strategy including achievement and maintenance of high immunization levels, effective surveillance to detect all new cases, and rapid and vigorous response to the occurrence of cases.

At this point it is appropriate to consider some of the characteristics of the polio vaccines available. Each has strengths and weaknesses and each has demonstrated its ability to provide individual protection and, in industrialized countries, to control or eliminate poliomyelitis.

Inactivated poliovirus vaccine (IPV)

IPV requires injection but it can be combined with diphtheria and tetanus toxoids and pertussis vaccine (DTP) and thus does not require a separate series of injections. Although of variable potency in the first years after its introduction, IPV has been of reliable potency since the late 1960s. A primary series of 3 doses induces seroconversion in more than 90% of recipients. Widespread use of IPV reaching very high levels of immunization coverage (in excess of 90%) has been responsible for the disappearance of polio from Sweden, Finland, and Iceland, and its virtual disappearance from the Netherlands. While IPV has some effect in reducing the potential of transmission of wild poliovirus by vaccinees, this does not appear to be as marked as with OPV. Antibody titers decline with time in the absence of repeated exposure to polioviruses (whether wild or vaccine) but available evidence indicates that protection is long-lasting, and probably lifelong.

In the late 1970s improved IPV was developed in the Netherlands by Dr. Anton Van Wezel. Field trials in Europe and Africa established that 2 doses of IPV containing 40, 8, and 32 D-antigen units of Poliovirus types 1, 2, and 3, respectively, induced seroconversion in virtually 100% of recipients. Licensure of an improved IPV in the United States is imminent.

Since the Cutter incident of 1955, in which 79 recipients, 105 family contacts, and 20 community contacts developed poliomyelitis as a result of incomplete inactivation of the virus in IPV, no serious untoward effects have been reported in association with its use. However, its use has primarily been in countries with birth cohorts of 100,000 or smaller, so events occurring with a frequency of one in one million or so might not be noticed.

Oral poliovirus vaccine (OPV)

OPV is easy to administer, induces lasting immunity in a high proportion of recipients after a 3 dose course, induces local intestinal immunity which impedes the ability of the recipient to spread wild poliovirus on subsequent exposure, and can spread to those in close contact with the vaccinee, thereby protecting them. If administered simultaneously to a large number of persons in a community it is capable of interrupting the transmission of other enteroviruses (including wild polioviruses). It is this latter capacity which makes it particularly useful in controlling outbreaks of poliomyelitis. On the other hand, its performance in some tropical countries has not been as good as expected, it does not retain potency when exposed to heat (and therefore requires a "cold chain" of vaccine management from manufacturer to recipient) and, on rare occasion, it is associated with paralysis in either the recipient or someone in contact with the recipient.

We have recently reviewed the risks of OPV-associated paralysis based on experience in the United States 1973-1984. During that period 35 cases of paralysis were reported in OPV recipients and 50 in persons in contact with vaccine recipients (Table 1). In addition 6 cases of paralysis occurred in persons with no history of vaccine receipt nor contact with vaccinees but from whom vaccine-like poliovirus was recovered. The cases were not equally distributed with regard to the dose in series with which they were associated - approximately 80% of all cases occurred in association with the first dose of vaccine (Table 2). We estimate that the risk of paralysis in a vaccine recipient is 1:1.2 million first doses and 1:116.5 million subsequent doses.

For contacts, the risk is 1:1.0 million first doses administered and 1:25.9 million for subsequent doses. Overall the risk is 1:2.6 million doses of OPV distributed. This figure includes cases of paralysis occurring in individuals with compromised immune systems, who are particularly prone to develop vaccine-associated paralysis.

OPV has been highly effective in this country and in many other industrialized countries. Only 1 case of paralysis due to wild poliovirus has occurred in an individual who had received at least 3 doses of trivalent OPV manufactured in the U.S. This situation is to be contrasted with that in several developing countries, where vaccine failures are not uncommon, either because of inadequate vaccine handling, interference from other enteroviruses, or other factors which are not clear.

Global experience with polio vaccines

Widespread use of polio vaccines (primarily OPV) has led to the control or elimination of poliomyelitis in most developing countries and substantial control has been achieved in many developing countries, including China, where more than 80% of the country's 3,000+ counties are free of polio. In general, polio has been brought under control in countries achieving immunization coverage levels with OPV on the order of 80%. Unfortunately, coverage with polio vaccine in developing countries is far from adequate. The major experience to date with IPV has been in northern European countries and in some provinces of Canada. In these areas, high levels of coverage (in excess of 90%) have brought about elimination of disease and, at least in Sweden, freedom from circulation of wild polioviruses.

Several experiences in the past ten years demonstrate that polio elimination does not follow automatically with achievement of high levels of coverage. An outbreak of polio with more than 100 cases occurred in the Netherlands in 1977 in spite of greater than 90% coverage with IPV. Infection from that outbreak was carried across the Atlantic and caused small outbreaks of polio both in Canada (in a province in which IPV is used exclusively) and the United States (where OPV is used essentially exclusively). These outbreaks all occurred in persons whose religious beliefs led them to reject vaccination; there was no spread of disease outside these religious communities in any of the countries, illustrating the importance of relatively small groups of susceptible individuals in the perpetuation of limited outbreaks of this disease. An outbreak in Taiwan in 1982 also indicated that poliovirus could successfully infect unvaccinated individuals in the face of community OPV immunization levels on the order of 80%. Instances of OPV vaccine failure or failure to seroconvert after receipt of three doses of OPV have been reported from India, the West Bank of Israel, and Mexico.

Recent outbreaks of polio in Finland, Brazil, The Gambia, and Senegal have all raised questions about our ability to eliminate polio. In Finland, where no polio cases had been reported for nearly 20 years, an outbreak of Type 3 polio occurred in 1985-86. This appeared to result from a relatively impotent type 3 component of the IPV used in Finland. In Brazil, a type 3 outbreak occurred in the face of repeatedly successful national immunization days. Subsequent studies suggest that the type 3 component of the OPV used in Brazil may have been inadequately potent. An outbreak of Type 1 polio occurred in The Gambia in 1986 in spite of coverage levels with OPV on the order of 80%. Intensive investigation indicated a vaccine efficacy of approximately 80%, somewhat lower than anticipated. The same outbreak of polio involved Senegal, including two areas in which only IPV had been used in recent years. A case-control study in these areas yielded a point estimate of efficacy of two doses of the new, more potent, IPV of only 70%. The reasons for this lower-than-expected efficacy are not yet known but operational deficiencies are suspected.

Notwithstanding these setbacks, the general experience with polio vaccines has been very positive and it appears that the main considerations in achieving polio elimination or eradication are operational. In many developing countries the routine health services have proven inadequate to achieve satisfactorily high levels of vaccine coverage and a special technique, using nationwide immunization campaigns, has evolved. The most dramatic example of this approach has been in Brazil, where repeated epidemics occurred in the face of moderately successful routine immunization services. In 1980 a series of National Immunization Days was begun with major use of broadcast and print media to orient the population to the need for polio vaccination and then polio vaccines were offered on a single day throughout the country in more than 70,000 vaccination posts. The result of this approach has been a very high participation level and a dramatic decrease in the incidence of polio (Figure 4), until the Type 3 outbreak of 1986 (Figure 5).

Several other countries, particularly in the Americas, have adopted the approach of National Immunization Days as a means of focusing public and political attention on immunization. This has resulted, for example, in a temporary cease-fire being declared in the civil insurrection in El Salvador in order to vaccinate children in both rebel-held and government-held areas. Regardless of political ideology, a regional immunization day was held in Central America on April 7. These massive approaches offer several advantages in terms of focusing public and political support for immunizations. It is not yet clear if or how these intensive efforts will lead to sustained routine immunization services. Nonetheless, they clearly offer the opportunity for short-term gains which can help change social expectations - if such impressive gains can be made in the short run, should a society settle for less in the long run?

Conclusion

Experience to date indicates that in industrialized, temperate zone countries disease due to wild poliovirus can be eliminated by achieving high levels of immunization coverage with either IPV or OPV. In several developing countries, particularly in the Americas, dramatic declines in the incidence of poliomyelitis have also been achieved. However, in many tropical countries, the experience with administration of OPV in routine immunization services has not had the desired effect. In several American nations, massive administration of OPV in National Immunization Days has had a major impact on the occurrence of disease and it appears that, if this effort can be sustained, disease due to wild poliovirus can be eliminated. This is the primary approach being taken in countries in the Americas which have not yet achieved elimination of disease. The problems that will then arise relate to documenting the absence of wild virus transmission and eliminating the small number of cases of vaccine-associated disease. Laboratory innovations give promise that simplified techniques will be developed to allow easy characterization of polioviruses recovered from individuals or from sewage. Elimination of vaccine-associated disease may await discontinuation of routine polio vaccination or might be accomplished earlier through an increasing use of IPV, either alone or in combination with OPV.

It is clear that prospects for improved control over poliomyelitis are excellent. Eradication on a regional basis is clearly feasible in fairly short order. Global eradication is inevitable, although the exact timeframe is unclear at present.

SELECTED BIBLIOGRAPHY

Hinman AR, Koplan JP, Orenstein WA, Brink EW, Nkowane BM.
Live or inactivated poliomyelitis vaccine: An analysis of benefits and risks.
Amer J Public Hlth, in press

Horstmann DM, Quinn TC, Robbins FC, eds.
International symposium on poliomyelitis control.
Rev. Infect. Dis. 6 (Suppl 2):S301-S601, 1984.

Hovi T, Cantell K, Huovilainen A, Kinnurer E, Kuronen T, Lapinleimu K, Poyry T, Roivainen M, Salama N, Stenvik M, Silander A, Thoden CJ, Salminen S, Weckstrom P.
Outbreak of paralytic poliomyelitis in Finland: Widespread circulation of antigenically altered poliovirus Type 3 in a vaccinated population.
Lancet i:1427-1432, 1986.

Kim-Farley RJ, Rutherford G, Lichfield P, Hsv ST, Orenstein WA, Schonberger LB, Bart KJ, Lui KJ, Lin CC.
Outbreak of paralytic poliomyelitis, Taiwan.
Lancet ii:1322-1324, 1984.

Nkowane BM, Wassilak SGF, Orenstein WA, Bart KJ, Schonberger LB, Hinman AR, Kew OM.
Vaccine-associated paralytic poliomyelitis, United States: 1973 through 1984. JAMA 257:1335-1340, 1987.

Paul JR. A history of poliomyelitis. New Haven: Yale Univ Press, 1971

Figure 1

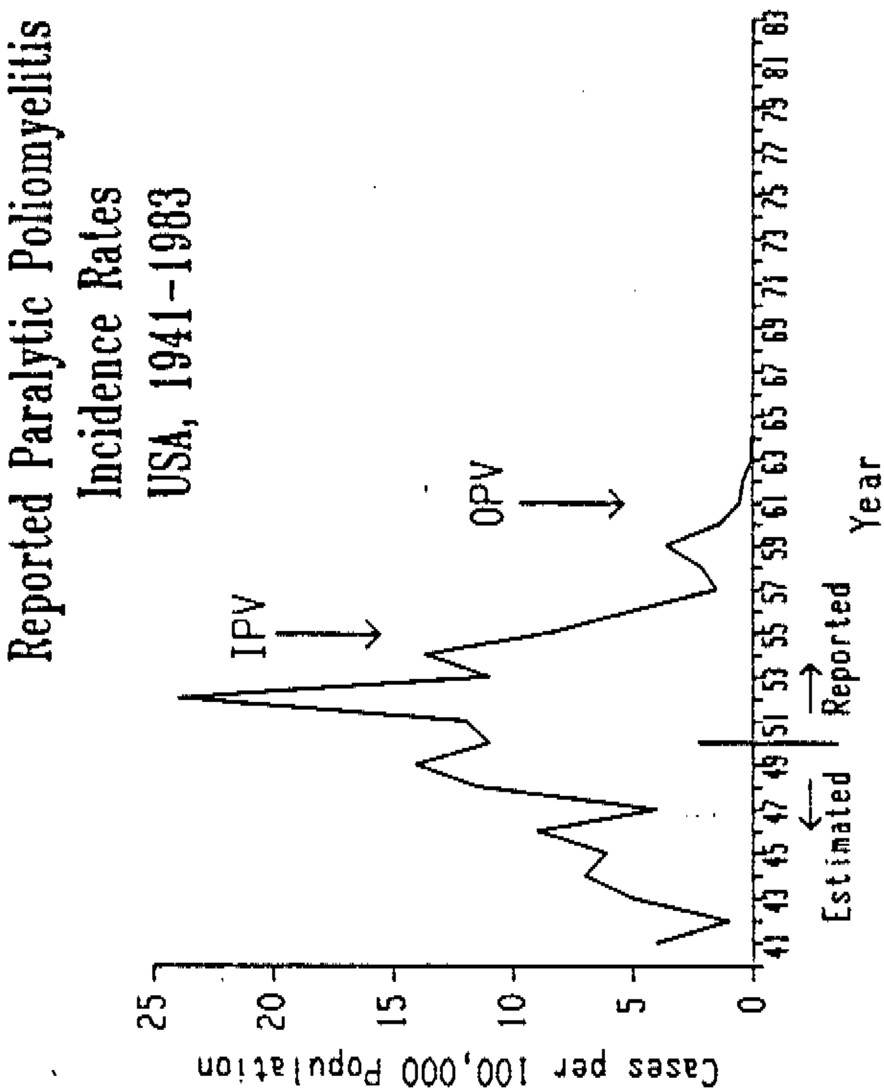
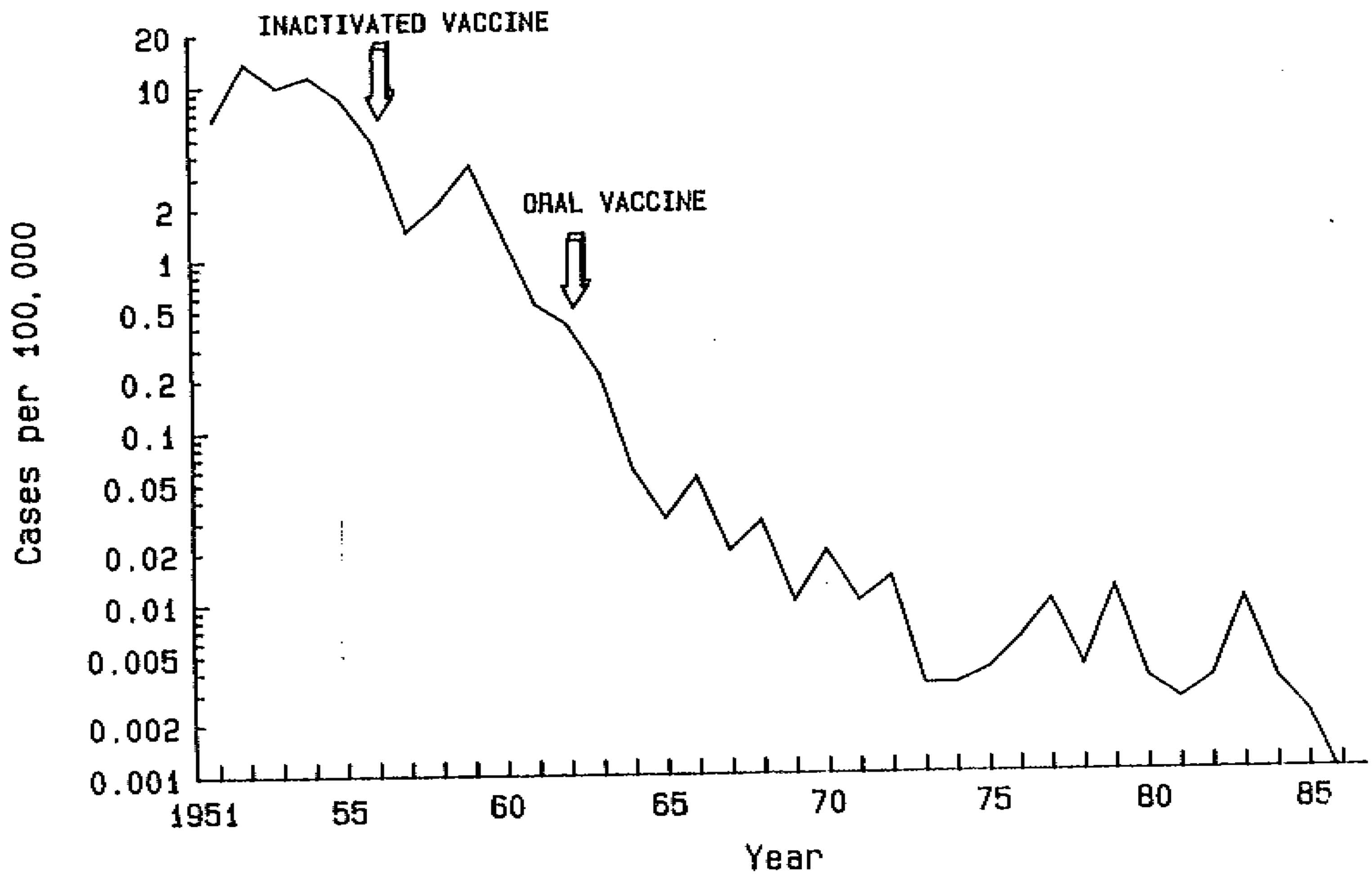

Reported Paralytic Poliomyelitis
Incidence Rates
USA, 1941–1983
IPV
OPV
Cases per 100,000 Population
25
20
15
10
5
0
41 43 45 47 49 51 53 55 57 59 61 63 65 67 69 71 73 75 77 79 81 83
Estimated
Reported
Year

Figure 2

Reported Paralytic Poliomyelitis Attack Rates, by Year, United States, 1951-1986*



*1985-86 provisional data
PHS, CDC, CPS, DI

Figure 3

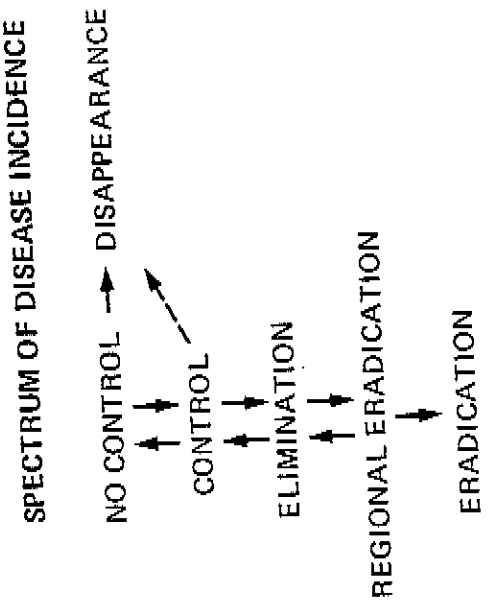

SPECTRUM OF DISEASE INCIDENCE
NO CONTROL
DISAPPEARANCE
CONTROL
ELIMINATION
REGIONAL ERADICATION
ERADICATION

Figure 4

Frequency of Cases of Poliomyelitis by 4–Week Periods, According to the Date of Disease Onset, Brazil, 1975–1986

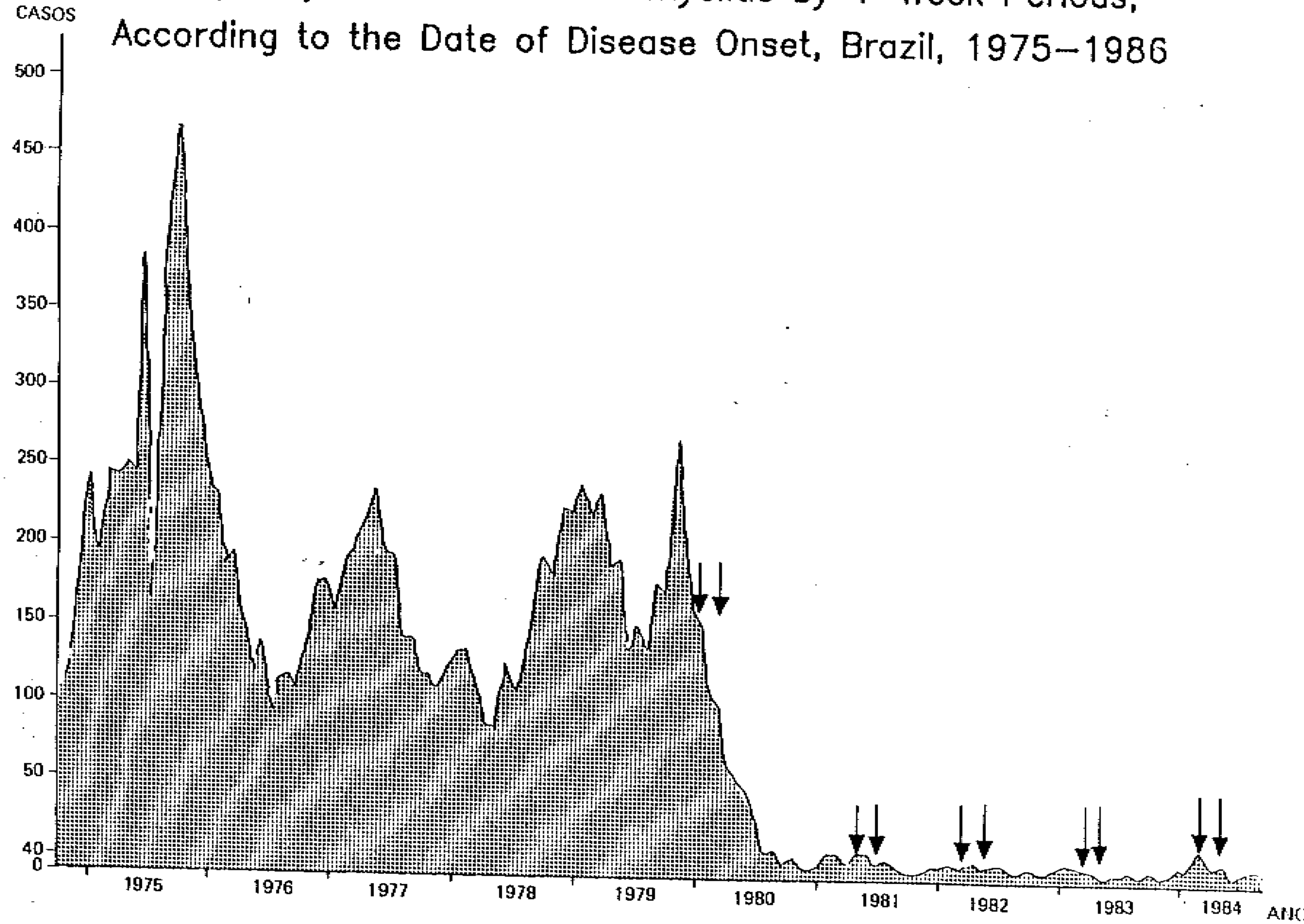
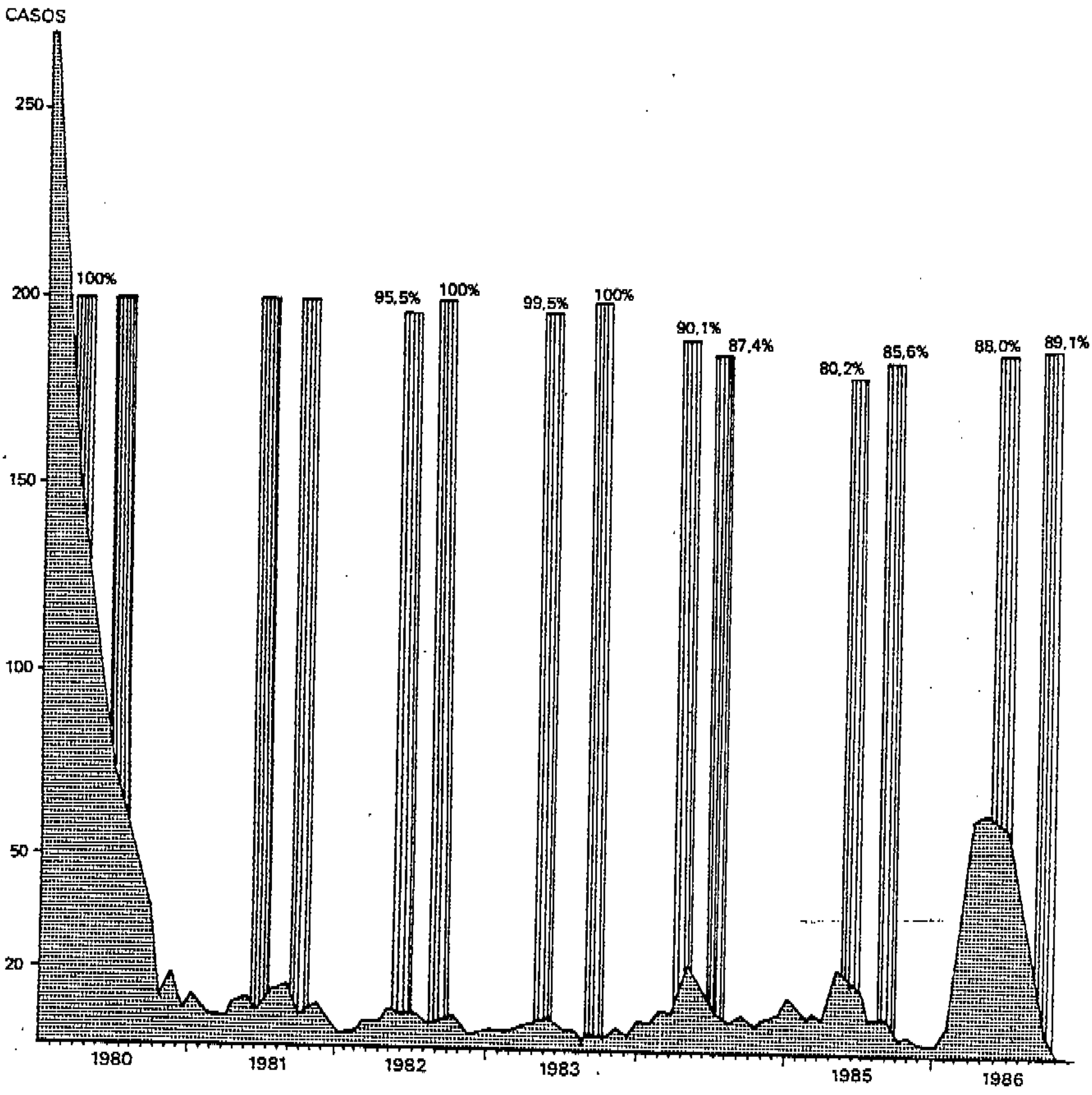


Figure 5

Frequency of Cases of Poliomyelitis by 4–Week Periods, and Vaccine Coverage Achieved on National Vaccination Days, Brazil, 1980–86



1. The shadded area refers to confirmed cases up to reporting week 44, 1986. The data for 1984, 1985 and 1986 are provisional, subject to modification.
2. The columns represent vaccine coverage in the group 0–4 years of age.