# Determining Community Immunization Level With Examples for Poliomyelitis

CHARLES R. HAYMAN, M.D., M.P.H.

THE IMMUNIZATION level of a community may be defined as the percentage of the population protected by natural and artificially induced immunity. The level is ultimately measured by the community's disease experience as evidenced by cases reported and otherwise discovered. This method of measurement is applicable to all communities, but it may be of little value when cases of disease are rare, as with smallpox, or infrequent, as with poliomyelitis. In Pennsylvania there were few cases of poliomyelitis in Berks, Lehigh, and Northampton Counties for 5 years before the mass vaccination programs of 1963, and only one case since (see table). However, there was a considerable potential as shown by sizable 1963 outbreaks in nearby Philadelphia and Cumberland Counties.

Case investigations necessary to validate the diagnosis include clinical, serologic, and virological studies on the patients. Such studies in Cincinnati were reported by Sabin (*1*) and in Czechoslovakia by Skovranek (*2*), as ruling out the diagnosis of poliomyelitis during 1960 and 1961.

Case attack rates will show whether differences exist between vaccinated and unvaccinated groups at one particular time and may show the influence of vaccination over a period of time. An example of a study at one point in time is Fendall's report on the epidemic in Kenya in 1960, with more than twice as many cases in the unvaccinated as in the vaccinated (*3*). Chin showed the decrease in case rates in Des Moines, Iowa, and Kansas City, Mo., from 1954 to 1959, concurrent with increased Salk vaccination (*4*).

The immunization level may also be measured by detection of antibodies in a representative sample of individuals as reported from South Africa (*5*). The most recent report describes a survey of children 1 through 4 years of age in Cleveland, Ohio, following an oral vaccination program in 1962. Titers were determined in vaccinated and unvaccinated children. Advances in laboratory methods may bring periodic sero-immunity surveys within the capabilities of many health departments (*6*).

Intestinal infection occurring naturally or produced by ingestion of vaccine may be demonstrated by identification of virus in patients and in sample surveys. Both were done in Israel before and during an outbreak of poliomyelitis in 1961 (*7*). Spread of virus may be shown by its recovery from sewage as was done in Hillsborough County, Fla. (*8*).

### Enumeration of Vaccine Recipients

An approximation of the community immunization level may be made by determining the number of individuals who have been vaccinated and the number of types of vaccine received by each. This is, in effect, an assessment of the success of mass campaigns and of auxiliary efforts by physicians and clinics.

The most complete method of enumeration is the use of a written registration for each individual, showing data such as age, sex, residence, and so forth, with tabulation and analysis of all cards. When registration is repeated for each type, card matching is necessary to deter-

*Dr. Hayman is associate director for preventive services, District of Columbia Department of Health. He was formerly medical director of region VI, Pennsylvania Department of Health, West Reading.*

mine the number of doses and types of vaccine received.

In Hungary, where separate registration was used most extensively, it documented 100 percent vaccination of children 8 months to 16 years, many of whom were revaccinated once or twice. All children who "escaped initial vaccination for any reason" were included in subsequent series (*9*).

The method was used in Berks and Northampton Counties, Pa., for all registrants except children vaccinated in schools. Major registration difficulties were that some residents did not know their legal address and that information on race was not easily obtained.

Processing was arduous, time-consuming, and costly, principally because of the tremendous volume of records, their illegibility, and movement of patients from one clinic to another.

In Berks County 171,256 persons received one, two, or three types of vaccine. Field data collection took approximately 10,000 man-hours, at a cost of $5,500. Preparation of punchcards and machine processing took approximately 500 man-hours at an estimated cost of $3,760 (*10*).

The modification most commonly used in community programs is separate registration for each dose with a rapid tally during the clinic operation. Data collection is necessarily restricted to total count and broad age groupings. It was used in Maricopa and Pima Counties, Ariz., in 1961 (*11*), Cleveland in 1962, and Carbon County, Pa., in 1963 (personal communications from Dr. C. L. Leedham, Cleveland Academy of Medicine, and Dr. C. W. Potter, Carbon County, Pa., Medical Society).

Separate registration for each dose and a rapid tally gives a good picture of coverage of the general population in broad age groups, and findings can be publicized during and immediately after the clinic day. However, rapid hand tallying by many volunteers often results in errors. Since registrations for each type are not matched, identity and percentage of persons receiving one, two, or three types can only be approximated. However, this estimate may be close enough for most purposes when done on a large enough population, such as that in the Cleveland area.

**Reported cases of poliomyelitis in Pennsylvania and three selected counties, 1958–63**

| Year | State | Berks | Lehigh | Northampton |
|---|---|---|---|---|
| 1963 | 105 | 1 | 0 | 0 |
| 1962 | 21 | 0 | 0 | 0 |
| 1961 | 53 | 4 | 1 | 0 |
| 1960 | 150 | 2 | 0 | 1 |
| 1959 | 193 | 2 | 3 | 8 |
| 1958 | 136 | 3 | 0 | 0 |

A simpler modification is complete registration with tabulation and analysis of a proportionate sample of the registrations. This approach was used in Cincinnati where a sample of 2,000 records of children was tabulated (*12*). In Lehigh County, Pa., we tabulated every third participant's record—about 60,000. Statistical accuracy depends on the size of the original sample, the proportion of records chosen, and the randomness of the selection.

Recipients may be enumerated without registration, simply by counting or tallying persons as they enter or leave the clinic, a method used in South Africa (*13*) and other countries where self-registration was difficult and volunteer or clerical help was not readily available. In New Zealand, "a series of numbered paper slips" were tallied (*14*). Tallying was done in Schuylkill County, Pa. (personal communication, Dr. R. Lyons, Schuylkill County Medical Society) and elsewhere in Pennsylvania and other States, but no reports have been published.

Another variation is a tally of bottles of vaccine. Number of doses per bottle are calculated, a correction is made for waste, and number of persons vaccinated is estimated. There is, of course, much chance of error. This approach was used in Delaware County, Pa., in addition to a tally of persons (personal communication, Dr. R. Plotkin, Delaware County Medical Society). It was probably the single method used in some other Pennsylvania communities and in other States.

### Interviews

Serfling has described an interview procedure without registration or tally in which one simply selects a stratified random sample of house-

holds and interviews the mother (preferably) about the past vaccination experience of all family members (*15*). Advantages are that a very small sample may be used and the survey completed in about 1,000 man-hours, as compared with 10,000 spent in making a complete registration and tabulation in Berks County. Most important, the survey includes both the unvaccinated and the vaccinated.

Interviewing before and after the program establishes the baseline and success of the effort. Such surveys have apparently been conducted in 125 cities, mostly before starting new programs, to assess disease experience and immunization by DTP, Salk, or Sabin vaccines.

One disadvantage is that the findings depend principally on the accuracy of the mother's memory, which diminishes with time Also, there is a sampling error, inversely proportional to the number interviewed, when the sample is small. Rural areas are hard to survey because of the low density of population. Thus in Berks County, outside of Reading, there were 37 census tract areas studied by registration; each of these would have needed a representative sample survey if the interview method had been used.

In Harrisburg, Pa., interviews were conducted to determine some of the factors influencing participation or nonparticipation in the Sabin program of 1961 (*16*). In Lebanon County, Pa., the method was tested in December 1962 against records of 142 persons in 47 families whose Salk vaccination status was known. On interview, the families reported 570 injections compared with 601 previously recorded. In June 1964 the method was tested against the Berks County complete registration and tabulation experience, and close agreement was found. The study results will be published subsequently.

Another procedure, advocated by the Public Health Service (*17*), is the survey of all children entering the first grade. This is usually accomplished by having the parents answer an official request for information around the time of school entrance. As in the interview method, information is supplied from memory and records given to the mother by physicians and clinics. In 1954, such a study on smallpox and DTP immunization was done in Maryland (*18*).

The findings of a 1961 survey of DTP and poliomyelitis immunization were reported for the 12 counties in this health region of Pennsylvania (*19*). A similar approach uses a questionnaire sent to mothers of all children still alive 2 or more months after birth. Information is also obtained from nonrespondents by phone or home visit. The most recent report describes its use in Memphis-Shelby County, Tenn. (*20*).

It is unlikely that any mass programs have been carried out without any sort of a tally whatsoever, since vaccine and other materials must be ordered in advance and frequently replenished by transfer from slow to busy clinics during the mass operation. However, communities which have had no mass programs will have no count of vaccinations performed in private offices and clinics unless a specific effort has been made to obtain it.

Finally, estimates or educated guesses have been made of the number of persons vaccinated over stated periods in large areas by using information assembled from the sources previously described and the records of shipments of vaccine by manufacturers.

Thus, Sabin estimated that "a total of about 30 million persons (in 11 countries including the United States) had received this vaccine for the first time in 1961" (*21*). A manufacturer estimated "that 35 million Americans have had at least one dose of the (manufacturer's) vaccine . . . through the end of 1963" (*22*), and the Communicable Disease Center, Public Health Service, estimated that 104 million doses of type 1 had been distributed in the U.S. through May 1964, of which at least 10 percent was not administered because of waste (*23*).

## Summary

The need for and effectiveness of intensive vaccination programs may be shown by determining the immunization level of a community. This is ultimately measured by disease experience, through cases reported and otherwise discovered, and confirmed by clinical and laboratory studies.

For diseases with low incidence, such as poliomyelitis, the need for immunization programs cannot be determined by cases but may be as-

sessed by serologic and virological surveys and enumeration of vaccine recipients in the population, particularly susceptible children. These methods will also measure the success of vaccination programs.

The number of persons who have received vaccine and their proportion in the community is measured most accurately by complete registration and tabulation, which takes the most time and money. Less accurate are tallying or sampling of registrations and tallying of recipients or vaccine used. Approximations may be made with least effort without registration or tally by questionnaire or interview of whole groups or selected samples. For a continuous assessment of immunization levels in most communities, the most practical approaches are questionnaires and visits to mothers of infants, questionnaires on all children entering school, and interviews of a stratified sample of households.

#### REFERENCES


(*1*) Sabin, A. B.: Community-wide use of oral poliovirus vaccine. Amer J Dis Child 101: 546–567, May 1961.

(*2*) Skovranek, V., and Zacek, K.: Oral poliovirus vaccine (Sabin) in Czechoslovakia. JAMA 176: 524–526, May 13, 1961.

(*3*) Fendall, N. R. E.: Poliomyelitis in Kenya: The 1960 epidemic and oral vaccine campaign. J Trop Med Hyg 65: 245–255, October 1962.

(*4*) Chin, T. D. Y., and Marine, W. M.: The changing pattern of poliomyelitis observed in two urban epidemics: Kansas City and Des Moines, 1959. Public Health Rep 76: 553–563, July 1961.

(*5*) Gear, J.: Background to the poliomyelitis vaccination campaign. S Afr Med J 37: 499–502, May 11, 1963.

(*6*) Lepow, M. L., Serfling, R. E., Sherman, I. L., and Robbins, F. C.: Immunization levels after oral poliovaccine. JAMA 187: 749–757, Mar. 7, 1964.

(7) Yofe, J., et al.: An outbreak of poliomyelitis in Israel in 1961 and the use of attenuated type I vaccine in its control. Amer J Hyg 76: 225–238 (1962).

(*8*) Neill, J. S.: Oral poliomyelitis immunization program in Florida. Public Health Rep 77: 592, July 1962.

(*9*) Dömök, I.: Some results of country-wide vaccinations against poliomyelitis with Sabin's attenuated strains in Hungary. Arch Ges Virusforsch 13: 98–103 (1963).

(*10*) Hayman, C. R., et al.: Oral polio vaccination programs in Berks County, Pa. Public Health Rep. In press.

(*11*) Johns, R. B., Farnsworth, S., Thompson, H., and Brady, F.: Mass immunization programs with Sabin oral vaccine. JAMA 183: 171–175, Jan. 19, 1963.

(*12*) Cockburn, T. A., et al.: Cincinnati's poliomyelitis immunization and surveillance program in 1961. Public Health Rep 77: 589–592, July 1962.

(*13*) Smit, W. A.: The national poliomyelitis campaign 1961. S Afr Med J 37: 504–510, May 11, 1963.

(*14*) Taylor, D.: Oral polio campaign . . . An exercise in teamwork. Int J Health Educ 6: 136–142, July–September 1963.

(*15*) Serfling, R. E., and Sherman, I. L.: Survey evaluation of three poliomyelitis campaigns. Public Health Rep 78: 413–418, May 1963.

(*16*) Fletcher, T. F., Jr., and Procopio, F.: Organized medicine and polio control with Sabin vaccine. [Brochure of scientific exhibit.] Dauphin County Medical Society, Harrisburg, Pa., June 1961.

(*17*) Surgeon General's Committee on Poliomyelitis Control, January 1961: Recommendations toward poliomyelitis control. Public Health Rep 76: 375–377, May 1961.

(*18*) Hayman, C. R.: The vaccination and immunization history of children entering school. GP 10: 35–38, September 1954.

(*19*) Hayman, C. R.: Immunization status of children entering school. Penn Health 23: 6–7, Winter 1962.

(*20*) Forwinkle, E., Guthrie, N., and Hagood, J.: Efficacy of immunization reminder cards. Arch Environmental Health 8: 471–473, March 1964.

(*21*) Sabin, A. B.: Oral poliovirus vaccine. Recent results and recommendations for optimum use. Roy Soc Health J 82: 51–59 March–April 1962.

(*22*) Annual report for the year 1963. Chas. Pfizer & Co., Inc., New York, 1964, p. 1.

(*23*) Henderson, D. A., et al. Paralytic disease associated with oral polio vaccines. JAMA 190: 41–48, Oct. 5, 1964.