action of recalling the vaccine of one manufacturer was taken. At that time perhaps five million doses of vaccine had been administered including 300,000 doses of the involved manufacturer. This incident occurred at a time of year when the normal incidence of poliomyelitis was minimal. Had the incident occurred during mid-summer it would have been more difficult to discern.

(2) In the summer of 1962 this very problem was encountered when cases of poliomyelitis were reported largely among adult males who had received monovalent Type 3 oral polio vaccine. With only 12 cases reported, several of which were most bizarre, a special board chaired by the Surgeon General was convened to inquire into the problem. Although it took two years to resolve this one, the surveillance programme brought the problem to recognition on the basis of 12 cases among tens of millions of vaccinees.

(3) In 1964, routine reports were received of two cases of *Salmonella new brunswick* infection in infants who had consumed a popular brand of non-fat dried milk. Checking back on the surveillance records of this rare serotype revealed a slight increase in occurrence over the previous several months. Field investigation of those reports confirmed an association with non-fat dried milk. The full investigation revealed a total of 28 cases over a 6-month period. Extensive culturing of this product by the US Food and Drug Administration ensued. One large production plant was discovered to be heavily contaminated with *S. new brunswick*, and widespread contamination of other plants was also uncovered. As a result of this small and essentially routine surveillance operation all manufacturers of this important and popular food, produced in quantities of more than 100 million pounds a year, reviewed their production and quality control processes. Several large producers ceased production for a complete overhaul and reconstruction of their plants.

Limitations on the Term

In the evolution of the concept of surveillance over the past 20 years some enthusiasts have tended to expand its scope too far. In the WHO Malaria Eradication terminology surveillance embraces active measures of control, namely chemotherapy and insecticiding during the consolidation and maintenance phases of eradication. Some epidemiologists tend to define surveillance as synonymous with epidemiology in its broadest aspects including epidemiological investigation and research. This trend is, in my opinion, both etymologically unsound and administratively unwise. I favour the definition of surveillance as the general practice of epidemiology or epidemiological intelligence. The surveillance officer should be the alert eyes and ears of the health officer and he should advise regarding control measures needed, but the decision and the performance of the actual control operations must remain with the properly constituted health authority. Similarly the flow of surveillance data may well provide interesting leads for research investigations, but the actual performance of the research study should be recognized as a function separate from surveillance.

In conclusion, let us recognize that although surveillance as a term applied to disease problems as distinct from individual persons is of only recent vintage, the function is as old as epidemiology itself. Let us use the term wisely and recognize its proper limitations. Let us recognize that in our conduct of surveillance we should emulate the standard set by William Farr a century ago whose courage, comprehensiveness, fearlessness and epidemiological insight have not been equalled since.

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Epidemiological Surveillance with Particular Reference to the Use of Immunological Surveys

The national and global surveillance of communicable diseases was discussed at the XXI World Health Assembly in 1968 (unpublished document, A21/Technical Discussions/5) and generally recommended to the member states as a prerequisite for the effective control and prevention of communicable diseases (Langmuir 1963, Raska 1964, 1966). Morbidity reporting and mortality registration are generally considered as being of basic importance in surveillance activities. However, in view of the existing weaknesses of health services in most developing countries and the traditional apathy with regard to vital statistics of the medical sciences and public health services in many highly developed countries, the implementation of a surveillance programme for communicable diseases cannot wait until there is an improvement in morbidity and mortality reporting. Too much additional effort and time would be required. Fortunately, the surveillance of most infections does not depend solely on the availability of reliable morbidity data. Laboratory findings when standardized are objective, comparable and reproducible. Furthermore, immunological surveys could be made immediately in most developing countries with bilateral or international help. It is therefore evident that the

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extensive use of immunological surveys is of basic importance for the surveillance of communicable diseases, at both national and international level.

Due to modern facilities of conservation, transport and storage (in liquid nitrogen) of biological material for laboratory investigation (serum, plasma, blood cells), different and sometimes complicated laboratory investigations can be carried out outside the country involved long before its own national health laboratory services would be able to do so.

Once a country has set up a well co-ordinated collection of representative blood samples, it could, with the help of WHO, obtain basic information on the presence and extent of the spread of many infections. This would provide the necessary background for planning, analysing, executing and evaluating control measures. Surveillance activities also assist in the recognition and follow up of changing patterns of infection and facilitate the making of epidemiological forecasts.

The WHO Serum Reference Banks play a key role in WHO assistance in the implementation of immunological surveys in developing countries. Three laboratories were designated as WHO Serum Reference Banks in 1960 and 1961, two of which are functioning at the present time: One, at Yale University, USA, works predominantly for the Americas; the second, at the Institute of Epidemiology and Microbiology, Prague, works for Europe, Africa and part of Asia; the third, in Johannesburg, has been out of function since 1965. In 1970 a new one was designated at the National Institute of Health in Tokyo with its field of activities in the Western Pacific Region. A new computer-controlled system of registration and handling of sera and of laboratory results has been developed in these Serum Reference Banks. The main objectives of the WHO Serum Reference Banks are:

(1) To receive and process human and animal sera, and eventually the corresponding blood cells and other biological material, provided they are accompanied by the necessary and pertinent epidemiological (ecological) documentation.
(2) To provide storage facilities and catalogue the sera and other material.
(3) To advise on the planning and implementation of immunological surveys.
(4) To provide assistance in the execution of immunological surveys in developing countries, giving on-the-spot technical advice and other help in the collection, processing and transport of sera to the WHO Serum Reference Banks.
(5) To carry out immunological surveys, either directly or in co-operation with other WHO Reference Centres or co-operating research institutions.
(6) To disseminate information on the results obtained and on the existing human and animal sera collections making this material available to other research institutions, if necessary or scientifically justified.
(7) To study new aspects in the collection (sampling methods), processing, storage and investigation of blood from human and animal populations and analyse the results gained.
(8) To facilitate, in co-operation with other research institutions, investigations in the field of noninfectious diseases of different hæmatological, biochemical, genetical and other factors in sera or blood cells collected from man or animals.
(9) To assist in future research by storing sera for 'posterity' studies.

In the last few years invaluable results have been obtained through the serological investigation of blood samples from more than fifteen countries in Africa, Asia, the Americas and Europe of the following: Poliomyelitis, measles, different arbovirus infections, rubella, influenza and other respiratory virus infections; diphtheria, pertussis, parapertussis, streptococcal infections, brucellosis, cholera, plague; syphilis and endemic treponematoses; typhus, Q fever; toxoplasmosis, trichinosis; malaria and amœbic dysentery. In addition, some of these collections of sera were investigated with regard to different enzymes and other factors.

Priorities in the control of communicable diseases are dependent on the feasibility of their prevention and, in giving examples of the use and results of immunological surveys, I will stress diseases for which effective vaccines are available. The WHO programme has been implemented during the last 5 years in developing countries only. Consequently, most of these countries have only preliminary results to date or at best have gathered just the basic information. I will therefore start with some results of immunological surveys in Czechoslovakia, where we have had practical experience of all aspects of their use for more than 15 years.

Until 1957 there was a relatively high incidence of paralytic poliomyelitis in Czechoslovakia. After immunological surveys had been carried out by Zacek in 1957 (Zacek *et al.* 1959) in several regions of the country, a decision was taken as to which age-groups of the population should be vaccinated, using three doses of Salk vaccine in 1957 and 1958. Since then, repeated yearly immunological surveys showed that the results of vaccination with Salk vaccine (three doses, 0·2 ml intracutaneously) were not satisfactory and, after a preliminary study in one region, mass vaccination using Sabin oral vaccine was started in 1960 with rapid disappearance of the disease. Figs 1, 2 and 3 show the poliovirus antibody levels after vaccination with Salk vaccine in 1958 and after using Sabin vaccine in 1961, 1963 and 1966. Parallel with these findings, a radical decrease in

the circulation of wild polioviruses was observed (Zacek 1969, personal communication).

In many tropical and subtropical countries the populations from early infancy have a solid immunity against poliomyelitis without any manifestation of paralytic illness, but the ecological situation may quickly change due to the influx of populations with high birth rates from rural areas into rapidly growing cities. In a few years this can easily create sufficient numbers of non-immune infants and young children to result in sizeable epidemics of paralytic poliomyelitis. In 1964 an epidemic of poliomyelitis with 350 cases occurred in Ibadan, although in the rural areas of Nigeria the early age-groups possessed very high levels of antibodies. The immunity status of the child population of Ibadan was much lower than in rural areas and the immune response after vaccination was not satisfactory (WHO 1966).

Measles is a major cause of death in infants and small children in some tropical areas and this was the reason for the introduction in 1967 of mass immunization against measles, coincident with vaccination against smallpox, in 20 West African countries with the help of the US Public Health Services and the US Agency for International Development. The results of immunological surveys facilitate decisions on vaccination programmes, which vary according to age-groups in different countries or even from area to area in the same country. In view of the high cost of measles vaccine, the conclusions of such surveys not only facilitate the work to be carried out, but also result in economic savings (Strauss 1970).

The introduction of universal immunization against diphtheria has radically decreased the incidence of this disease in most of the developed countries of the world. Dr B Kriz from the Institute of Epidemiology and Microbiology in Prague has developed a new colorimetric tissue culture test for quantitative measurement of diphtheria antitoxin which fully corresponds to Jensen's classical test and which is very advantageous in comparison with Schick testing (Kriz *et al.* 1970).

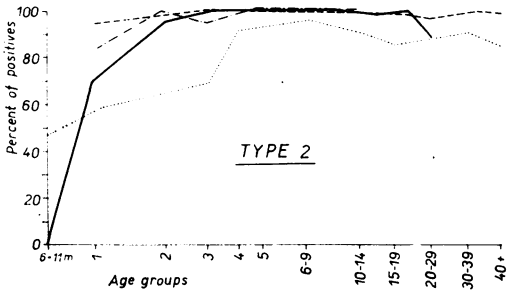

Fig 2 *Age distribution of neutralizing antibodies to Type 2 poliovirus in the general population of one area of Czechoslovakia (1958–66).* ...., *November 1958.* ----, *December 1961.* ·····, *December 1963.* ————, *December 1966*

Antitoxic immunity has been shown to be very high in the populations of Kenya (Fig 4), Togo and Nigeria. It is well known that in these countries classical diphtheria faucium is extremely rare; no cases are notified nor is diphtheria immunization practised. The high antitoxin levels are caused by very common chronic skin infections with *Corynebacterium diphtheriæ* and group A streptococci. It is evident that at the present time there is no need for diphtheria immunization in the rural areas of these countries, but an increase of diphtheria faucium can be expected in the near future in the child populations of African cities when exposure to infection from repeated skin scratches or mosquito bites has been diminished.

A serological investigation of the non-immunized population in Kabul, Afghanistan, has shown a different natural history of the disease. Diphtheria is here a serious public health problem and about 40% of clinical cases occur

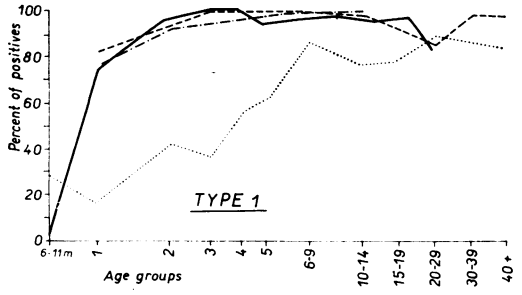

Fig 1 *Age distribution of neutralizing antibodies to Type 1 poliovirus in the general population of one area of Czechoslovakia (1958–66).* ...., *November 1958.* ----, *December 1961.* ·····, *December 1963.* ————, *December 1966*

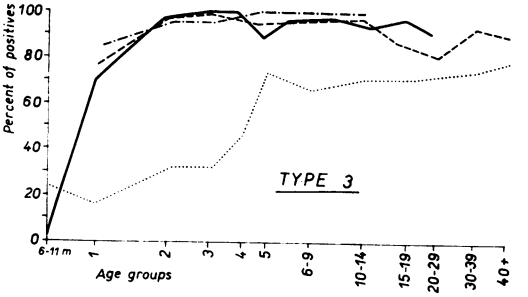

Fig 3 *Age distribution of neutralizing antibodies to Type 3 poliovirus in the general population of one area of Czechoslovakia (1958–66).* ...., *November 1958.* ----, *December 1961.* ·····, *December 1963.* ————, *December 1966*

in older children and young adults aged between 12 and 20. Diphtheria was also a serious health problem until 1966 in Mongolia, in spite of claimed mass vaccination; the immunological investigation of blood samples taken from the population of Ulan Bator clearly illustrates the reasons for the continuing spread of the disease (Fig 5). As a result of these findings systematic and well-controlled immunization against diphtheria, pertussis and tetanus was implemented with the help of WHO in 1967 and 1968 and the incidence of diphtheria decreased sharply in the following two years. It is certain that repeated immunological investigations of the population of Ulan Bator, Mongolia, which will be performed in the near future in the Prague Serum Reference Bank, will show a definite increase in the diphtheria antitoxic immunity among children of this country.

Fig 6 shows the antitoxic immunity levels in the population of a district in Prague in 1965, where systematic immunization was introduced more than 23 years ago. In the last 5 years there have been no cases of diphtheria among children in Prague and only a few sporadic cases among adults. The circulation of toxigenic strains of *C. diphtheriæ* in the population has certainly decreased, but still exists.

Whooping-cough still represents a very serious health problem in many countries in the world. The use of effective vaccine against *Bordetella pertussis* has radically diminished morbidity and mortality in several highly developed countries, but the problem is still far from solved in other parts of the world. There are two main reasons for this state of affairs: First, whooping-cough can be caused by two etiological agents, *B. pertussis* and *B. parapertussis*, which are antigenically unrelated. *B. parapertussis* is well recognized as an important cause of whooping-cough in many European countries. For example, in Czechoslovakia, where an effective vaccine against *B. pertussis* has been used for the last 12 years, and where the whooping-cough morbidity rate has decreased from 398 per 100,000 in 1957 to

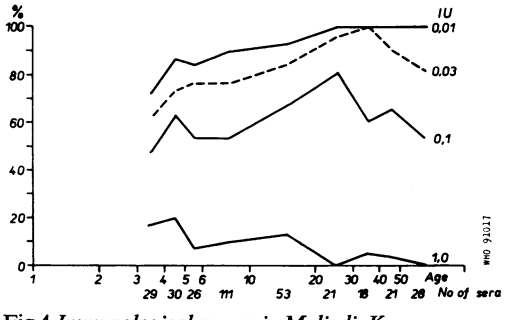

Fig 4 *Immunological survey in Malindi, Kenya: diphtheria*

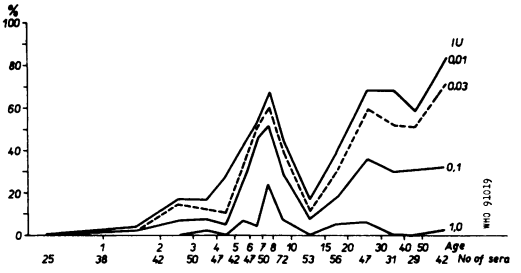

Fig 5 *Immunological survey in Ulan Bator, Mongolia: diphtheria*

63 per 100,000 in 1967, *B. parapertussis* is now a cause of whooping-cough in more than 75% of cases. Immunological surveys in twelve countries in Africa and Asia have demonstrated the circulation of *B. parapertussis* in the populations of all these countries.

The second reason for the persisting importance of the world-wide whooping-cough problem lies with difficulties in the production or use of a good and effective vaccine. Immunological investigations of rural populations of Togo and Kenya have shown that the strains of *B. pertussis* causing whooping-cough in these countries have a very different antigenic composition. In both investigated areas the population was not immunized against pertussis. In another study Vysoka-Burianova *et al.* (1970) analysed under controlled conditions the antigenic composition and immunogenic properties of eight pertussis vaccines that are produced and used in Central and Western Europe. The results gained illustrate the very different antigenic composition of these vaccines and antibody response among vaccinated children. All these findings support the view that the surface antigens of *B. pertussis* might play an important role in the immunogenic potency of the vaccine.

Mongolia is one of the few areas of the world where toxoplasma infections are practically absent in the human population. *Toxoplasma gondii* antibodies in a low titre were found in only one serum, taken from a person aged 30, out of

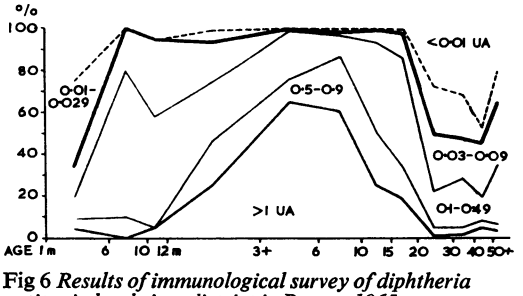

Fig 6 *Results of immunological survey of diphtheria antitoxin levels in a district in Prague 1965* (*Kriz* et al. *1970*)

about 1,300 investigated sera in a representative population sample in Mongolia. However, at the same time toxoplasma antibodies were found in a relatively high percentage of investigated animal sera of cattle (41·3%), sheep (19%) and goats (29·2%). It is of great interest that domestic cats are not kept in Mongolian families (Hutchison *et al.* 1970). It is natural that these and other similar findings are provoking further questions and ecological epidemiological investigations.

Immunological surveys are of course only the first, but very important, step in global surveillance and in the study of the geographical pathology of communicable diseases (Raska 1970). Fully developed surveillance activities differ according to the infection. The spread of infections is continuously influenced by complex and changing social and natural conditions. There is no doubt that immunological surveys, carried out as part of the epidemiological surveillance programme in developing countries with the help of WHO, also enable the Organization to provide improved and scientifically based advice on the planning and implementation of communicable disease control. In addition, they effectively stimulate the strengthening of epidemiological and microbiological services in these countries.

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Our two principal speakers have clearly defined the scope of surveillance, an important concept which may not always be easy to separate from other activities relevant to the control of disease. Those of us who are immersed in day-to-day problems of control have to a degree been engaged in surveillance as an integral part of normal public health practice and we may be too close to the subject to see it in perspective. So this clearer definition is welcome.

Some of the observations and records on which surveillance is based may be collected by means of studies specifically designed for the purpose, like the serological surveys described by Dr Raska. Others may have been assembled primarily for different uses and serve only secondarily for surveillance activities. Demographic data, for example, have a wide application to economics, sociology and public health generally and it is almost an incidental feature that the same data supply the denominators, such as the age and sex distributions of a population, which are essential to epidemiological analysis. Dr Langmuir, in his description of the Cutter incident, mentions the use made of knowledge of the quantities of poliomyelitis vaccine distributed by different manufacturers and, in Britain, we have seen that records of the total weekly new claims to sickness benefit, compiled primarily for economic reasons, have proved useful in the surveillance of influenza. There is an element of opportunism, as well as design, in all this. Even such obviously relevant records as those derived from the notification of infectious disease were developed originally more in the context of control than of surveillance.

But the keeping of records does not constitute surveillance. There is a need to synthesize the facts into some coherent whole and, as Dr Langmuir has stressed, to communicate both the facts and the synthesis to those who have provided the data and to those who need to know about them for purposes of control. The Surveillance Reports issued from the Center for Disease Control cater for this need. So, in Britain, do the Communicable Disease Reports of the Public Health Laboratory Service. The publication of material selected from these reports in the weekly medical press is a welcome development. There is a further need, as Dr Raska has indicated, for international collaboration and for studies specifically designed for surveillance purposes.

Surveillance seems to me to occupy a position midway between public health activities and epidemiological research, utilizing the resources of both and feeding back suggestions for further developments. It is characterized by an attempt at comprehensiveness and continuity and one of the difficulties in its path is to persuade busy practitioners and public health workers to record and communicate information for which they cannot always see an immediate practical use. This is why the feed-back is so necessary. When people can see the purpose of their effort they are far more willing to continue it.