Bull. Org. mond. Santé }
Bull. Wld Hlth Org. } 1960, **22**, 203-213

Vaccination with the CHAT Strain of Type 1 Attenuated Poliomyelitis Virus in Léopoldville, Belgian Congo*

1. Description of the City, its History of Poliomyelitis, and the Plan of the Vaccination Campaign

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A trial of the CHAT, type 1, attenuated poliovirus strain of Koprowski was begun in August 1958 in Léopoldville, a city of 350 000 people, and possessing modern medical facilities, including an institute of public health.

Paralytic poliomyelitis is endemic in the city; since 1951 there has been an average annual incidence of 63 cases, and a rate of 19.4 cases per 100 000 inhabitants. More than 80 % of the cases have occurred in African children less than 3 years old. Consequently, a plan to vaccinate African infants and children was formulated and put into operation.

Vaccination was performed by squirting virus into the mouths of the children at medical dispensaries or special clinics. The innocuity of the vaccine was checked by follow-up visits to the homes of a large number of children one and two weeks after virus feeding. Blood specimens were taken before and after virus administration to determine the initial susceptibility of the population and their response to live-virus vaccination. The results of vaccination are presented in the following paper.

In 1957 and 1958, Courtois and co-workers conducted the first mass vaccination trial with attenuated living poliovirus (Courtois et al., 1958), using the type 1 CHAT strain of Koprowski (1957). More than 250 000 persons in the Belgian Congo and Ruanda-Urundi were vaccinated without untoward reactions. The results of this trial were of great importance to those responsible for public health in Léopoldville, the largest city in the Belgian Congo.

Since the collection of accurate morbidity data, beginning in 1951, it had become clear that poliomyelitis was endemic and epidemic in the city. The average annual incidence of paralytic poliomyelitis among African residents of Léopoldville from 1951 through July 1958 was 18.8 cases per 100 000 inhabitants, or about 58 cases per year.

In view of the existing problem, it was decided to vaccinate the susceptible African population against

* This work was supported in part by research grant E-1799 from the National Institutes of Health, Public Health Service, US Department of Health, Education, and Welfare.

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poliomyelitis. Living virus vaccine was preferred over inactivated virus vaccine for the following reasons:

(1) Oral administration facilitates mass vaccination and precludes the transmission of disease through failure to change needles when parenteral inoculation is used in large populations.

(2) By analogy to vaccination with living virus vaccine against yellow fever, we hoped to produce immunization that would be both effective and long-lasting, thereby not requiring booster doses in the future.

(3) Immunization could be completed before the age at which children became susceptible, which on the basis of past morbidity data (see below) was about 6 months of age.

(4) Killed virus vaccine would have been prohibitively expensive to obtain and to administer.

In addition to these advantages of living virus in achieving the objective of immunizing the population, from the scientific point of view we hoped that the vaccination campaign would also yield further knowledge concerning certain aspects of the safety and effectiveness of the vaccine. Although these studies have not yet been completed, they have already provided some interesting information, which is reported here in four parts: the present paper describes the background and design of the trial; the next article, by Plotkin et al. (see page 215), describes its preliminary results; the third, by Gard (page 235) is a discussion of immunological strain specificity within type 1 poliovirus, including the strain administered in this trial; and the last by Koprowski et al. (page 243), deals with the identification of strains of poliovirus isolated from paralysed children in Léopoldville.

MATERIALS AND METHODS

The vaccine

The virus strain was the type 1 CHAT virus (Koprowski, 1957). The pool used, number 13 (Koprowski, 1959), had been tested for bacterial and fungal sterility and for the presence of extraneous viruses. It had also been inoculated into 45 monkeys by the intracerebral route, in a dosage of $10^{7.5}$ TCD_{50}, and into five chimpanzees by the intraspinal route. None of the primates thus inoculated developed clinical illness, and only one monkey had lesions of poliomyelitis on histological examination of the spinal cords.

The vaccine arrived in Léopoldville in the frozen state with a concentration of $10^{7.5}$ TCD_{50} of virus per ml. In Léopoldville the vaccine stock was divided into small vials, each containing 1 ml, which were kept in a freezer at −20°C. On the day of vaccination the contents of a 1-ml vial were diluted in 300 ml of neutral saline solution. The final concentration of the vaccine was therefore $10^{5.0}$ TCD_{50} per ml. For infants less than 30 days old 1 ml of concentrated vaccine was diluted to 20 ml in a medicine dropper bottle, giving a final concentration of $10^{6.2}$ TCD_{50} per ml.

The 300-ml bottles and the medicine dropper bottles of diluted vaccine were both kept on ice at 0°C throughout their subsequent use for vaccination. Any vaccine remaining in the large bottles was discarded at the end of the day, whereas the contents of the small bottles for infant use were used for two days. The titre of the vaccine after a day's use was checked periodically by sending frozen aliquots to the Wistar Institute, Philadelphia, Pa., USA. Titration of these samples showed good maintenance of virus titre.

Isolation of viruses from faeces and cerebrospinal fluid

Stools from paralysed patients were placed in screw-top vials, frozen, and sent to the Wistar Institute in Philadelphia or to the Institut Princesse Astrid in Léopoldville in that state. 20% stool suspensions were made in phosphate buffered saline (PBS), which contained 300 units of penicillin and 300 units of streptomycin per ml. The suspension was centrifuged at 5000 r.p.m. for one hour, and the resulting supernate recentrifuged at 12 000 to 14 000 r.p.m. for 2 hours. After separation, 0.25 ml of 0.4% of phenol red was added to each 10 ml of supernate, and the pH was adjusted to 7.5 if necessary.

Each specimen was then inoculated in 0.1-ml amounts into three monkey kidney tissue culture tubes containing 1 ml maintenance medium. The tubes were incubated at 37°C for one week and were examined microscopically for cellular destruction daily for seven days after inoculation.

In Léopoldville, the stools were also inoculated into suckling mice, which were observed for signs of neuromuscular disease. Mice which developed illness were sacrificed, and their musculature examined microscopically for the pathological manifestations of Coxsackie virus infection.

All negative stools were blind-passed once by inoculating fresh tubes with tissue culture fluid from the initial cultures. Cytopathogenic agents were identified by neutralization tests with antisera produced by inoculation of rabbits with living poliovirus of the Mahoney, MEF, or Saukett strains. These sera neutralized 100 TCD_{50} of homotypic virus even when diluted 1: 32 000. They were used at dilutions of 1: 60 to 1: 240.

Cerebrospinal fluid specimens were made up to 3 ml by the addition of PBS, and 450 units each of penicillin and streptomycin were added. After incubation for one hour at 37°C, 0.1-ml aliquots were inoculated into three monkey kidney tissue culture tubes, which were handled as stated above.

Collection of blood specimens

The bleeding was performed by physicians, using femoral or antecubital venipuncture. In order to avoid confusion of sera, the name of each child from whom a blood specimen was taken was recorded in a book and given a code number. The code number was stamped on a piece of adhesive tape which was then affixed to the child's arm. After collection of blood by means of a vacuum tube, the tape was transferred to the tube which was sent to the laboratory. The sera were separated and placed in glass ampoules, which were then flame-sealed. The adhesive tapes were transferred from the vacuum tube to the ampoule during the processing. The sera were kept frozen and sent to the Wistar Institute in Philadelphia in the frozen state for testing.

Neutralization tests

The sera were inactivated at 56°C for 30 minutes; diluted 1: 4; and then tested by the metabolic inhibition test (Lipton & Steigman, 1955) for the presence of antibodies to 100 TCD_{50} of the Mahoney (type 1), MEF (type 2), or Saukett (type 3) strains of poliomyelitis virus. The sera from paralysed patients were tested by a complement-fixation test against type-specific heated antigens of poliovirus by Dr Klaus Hummeler (unpublished data, 1959).

GENERAL INFORMATION CONCERNING LÉOPOLDVILLE

Léopoldville, the capital of the Belgian Congo, is situated on the lower Congo River, 300 km from the Atlantic Ocean. Its climate is tropical with a cool, dry season from June to September and a hot, humid season from October to May.

Excellent medical services and public health services are available, capable of maintaining carefully controlled observations on the effects of a living-virus poliomyelitis vaccine. Twelve hospitals, with an aggregate of 3624 beds, are situated in or near the city, and there are 42 out-patient clinics for Africans and three for Europeans. Some 50 physicians are engaged in active, clinical medicine, and 25 African medical auxiliaries, who have passed a six-year training course, deal with out-patients. Reference will be made later to the Institut de Médecine tropicale Princesse Astrid and the Institut d'Hygiène Marcel Wanson.

The rapid growth of the town, from 26 000 inhabitants in 1935 to 346 000 in 1958, has created difficult problems of urbanization. Alongside new sections where housing is of a fairly progressive type, there still exist older sections where Africans live in usually overcrowded houses built with the customary materials of primitive dwellings—mud walls and thatched roofs. Table 1 gives data on the present population of Léopoldville and the situation in each district with respect to housing and sanitation. Fig. 1 is an outline map of metropolitan

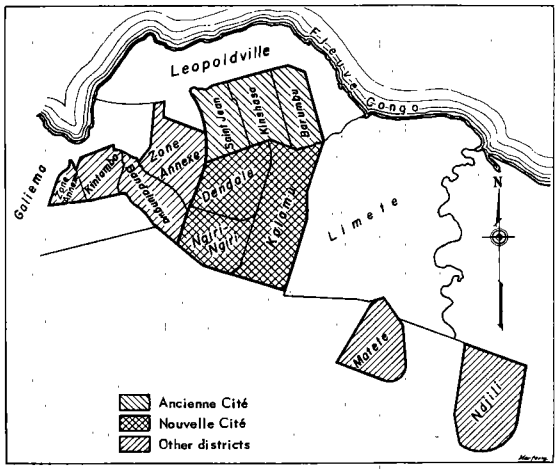
TABLE 1

POPULATION, HOUSING, AND WASTE DISPOSAL FACILITIES OF AFRICAN DISTRICTS OF LÉOPOLDVILLE

District	Population (in thousands)	Average No. of inhabitants per lot	Percentage of lots with	
			Pit privies	Bored-hole facilities
Ancienne Cité	125.8	18	100	—
Barumbu		19	100	—
Kinshasa		18	100	—
Saint-Jean		16	100	—
Nouvelle Cité	129.6	8.5	100	—
Dendale		11	100	—
Kalamu		5	100	—
Ngiri-Ngiri		13	100	—
Bandalungwa	13.2	4	90	10
Camp Léopoldville [a]		4	73	27
Matete	23.6	4	—	100
Ndjili	32.4	6	66	34
Kintambo	21.2	11	—	100
Total	345.5	11	73	27

[a] Military camps: population figure not available.

FIG. 1
LOCATION OF RESIDENTIAL AREAS FOR AFRICANS IN LÉOPOLDVILLE



Léopoldville, showing the major subdivisions referred to in Table 1.

Barumbu, Kinshasa, and Saint Jean form the densely overcrowded " Ancienne Cité ", where approximately 125 000 people live in huts and shacks with few sanitary facilities. Dendale, Kalamu, and Ngiri-Ngiri comprise the " Nouvelle Cité ", with a population of approximately 130 000. Although much of the housing in this section is in the form of European-type single dwellings, sanitary facilities still consist almost exclusively of pit privies. There are four other districts plus two military zones in metropolitan Léopoldville, as shown on the map. Kintambo is an old section of the city; however, the housing is sturdier and better built than in the Ancienne Cité, and bored holes have been provided throughout. The two " zones annexes " are the sites of military encampments, collectively referred to as Camp Léopoldville. Bandalungwa, Matete, and Ndjili are recently built housing developments of European type for Africans. In these areas, sanitation is accomplished by pit privies or by bored holes. In addition to the areas inhabited by Africans, the districts of Léopoldville and Limete are occupied by Europeans.

The age and sex distribution of the Léopoldville population is of interest, in that it reflects the economic situation. An excess of young adult males who have come to the city to find work reduces females to 45% of the population. Because of the departure of old people to the villages, a high proportion of the women are of child-bearing age, and consequently 21.7% of the Léopoldville African population (excluding the military camp) is under 5 years of age.

It is also of interest to note that the infant mortality rate in Léopoldville has decreased steadily, from 197 per 1000 in 1950, through 168 in 1953 and 87 in 1956, to 82 in 1958.

HISTORY OF POLIOMYELITIS IN LÉOPOLDVILLE

Although it is difficult to obtain accurate data on the past history of poliomyelitis in the tropics, we know that this illness has been present in Léopoldville for many years. Official documents in 1919 contain a report of a not inconsiderable epidemic that started in the lower Congo basin and was particularly active in the Léopoldville region. J. Rodhain[1] reported the age distribution for 59 cases during the 1919 outbreak which is presented in Table 2. It is notable that this epidemic affected a large number of young adults and that there was a high mortality rate, a circumstance which has not occurred since. This distribution led Rodhain to draw the conclusion that " the large proportion of adult patients seems definitely to show that the epidemic had flourished on virgin ground or at least had developed in an environment that had not for a long time come into contact with the Heine-Medin virus ". Rodhain isolated the virus in the monkey *Cercopithecus schmidti*, a remarkable accomplishment for the time.

TABLE 2
AGE DISTRIBUTION FOR 59 CASES DURING 1919 OUTBREAK OF PARALYTIC POLIOMYELITIS IN THE BELGIAN CONGO

Age (years)	No. of cases	Percentage of cases
½- 2	15	25.4
3- 7	27	45.8
8-12	3	5.1
15-20	2	3.4
21+	12	20.4
Total	59	100.1

[1] In a paper presented at the Ier Congrès de Médecine tropicale de l'Afrique Occidentale, Saint-Paul-de-Loanda, 1924.

TABLE 3
REPORTED CASES OF PARALYTIC POLIOMYELITIS AMONG AFRICANS IN THE BELGIAN CONGO, 1935-58

Year	Cases	Deaths	Percentage mortality
1935	6	4	67
1936	52	6	9
1937	14	—	—
1938	11	1	9
1939	4	2	50
1940	3	—	—
1941	28	4	14
1942	12	2	16
1943	12	2	16
1944	20	1	5
1945	8	—	—
1946	32	3	9
1947	52	—	—
1948	86	2	2
1949	77	2	3
1950	326	18	6
1951	447	27	6
1952	592	22	4
1953	707	48	7
1954	710	39	5
1955	1 447	77	5
1956	571	29	5
1957	564	34	6
1958	869	37	4

Only one case (in 1924) was registered for the period April 1920 through 1934. It is likely that the lack of reported poliomyelitis was the result of the preoccupation of the small number of physicians with the great epidemics of smallpox and sleeping sickness rather than of the absence of the disease. Table 3 gives the number of cases of paralytic poliomyelitis recorded between 1935 and 1958 for all the Belgian Congo. Accurate records of poliomyelitis in Léopoldville itself prior to 1951 are not available, but it should be noted that between 1935 and 1949 the disease was reported infrequently. Beginning in 1950, the number of reported cases grew rapidly; this was more likely the result of an increase in the number of physicians and the completeness of reporting than of an actual increase in the incidence of poliomyelitis.

Since 1951, the physicians of Léopoldville have been required to give complete information on reported cases of paralytic poliomyelitis, including the identity of the patient, the size and composition of his family, the type of paralysis, and other pertinent information. Table 4 gives the annual incidence of poliomyelitis in Léopoldville since 1951. The morbidity rate among Africans, except in 1954

TABLE 4
ANNUAL INCIDENCE OF PARALYTIC POLIOMYELITIS IN LÉOPOLDVILLE, 1951-58

Year	Africans					Europeans				
	Population (in thousands)	Morbidity		Case fatality		Population (in thousands)	Morbidity		Case fatality	
		Cases	Rate [a]	Deaths	Rate [b]		Cases	Rate [a]	Deaths	Rate [b]
1951	204	54	26.4	2	4	11.0	1	9.1	—	—
1952	224	65	29.0	—	—	13.3	5	37.6	1	20
1953	251	61	24.3	1	2	15.6	1	6.4	—	—
1954	331	15	4.5	—	—	15.2	4	26.3	1	25
1955	334	74	22.2	3	4	15.9	19	119.4	4	21
1956	362	78	21.6	—	—	19.1	4	21.0	—	—
1957	419 [c]	65	15.5	—	—	19.1	3	15.7	—	—
1958 [d]	346	27	15.0 [e]	4	5	19.7	1	5.1	—	—
Total		439		10			38		6	
Average	309	58	18.8	1.3	2.3	16.1	5	31.0	0.8	16

[a] Cases per 100 000 population
[b] Deaths per 100 cases
[c] The decline in population from 1957-58 reflects principally the effects of economic recession, which caused many young males to return to their home villages.
[d] Through July 1958
[e] Predicted for entire year

TABLE 5

PARALYTIC POLIOMYELITIS CASES AMONG AFRICANS OF LÉOPOLDVILLE BY MONTH, 1951-58

Year	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1951	19	10	0	1	3	5	10	2	2	0	1	1
1952	2	1	2	4	4	8	17	6	6	6	7	2
1953	10	3	1	2	1	1	4	4	6	9	15	5
1954	2	2	2	0	1	1	1	2	1	2	0	1
1955	7	6	12	23	7	6	3	3	3	3	1	0
1956	2	7	2	7	2	4	4	4	6	10	17	13
1957	10	5	2	5	3	1	0	5	8	3	8	15
1958	12	5	6	1	2	0	1					
Total	64	39	27	43	23	26	40	26	32	33	49	37

when it was abnormally low, varied between 15.5 and 29.0 per 100 000. The case fatality of the disease among Africans was low (2.3% of all cases). For the small European population, the case fatality rate was much higher (16% of all cases).

The seasonal distribution of paralytic poliomyelitis among Africans in Léopoldville is shown in Table 5 and in Fig. 2. It appears that epidemics occur principally during the hot season in December and January, but a large epidemic occurred in April 1955. In this connexion, it is interesting to note that transmission by flies does not seem to be

FIG. 2

SEASONAL VARIATION IN PARALYTIC POLIOMYELITIS CASES IN LÉOPOLDVILLE, JANUARY 1951 TO JULY 1958

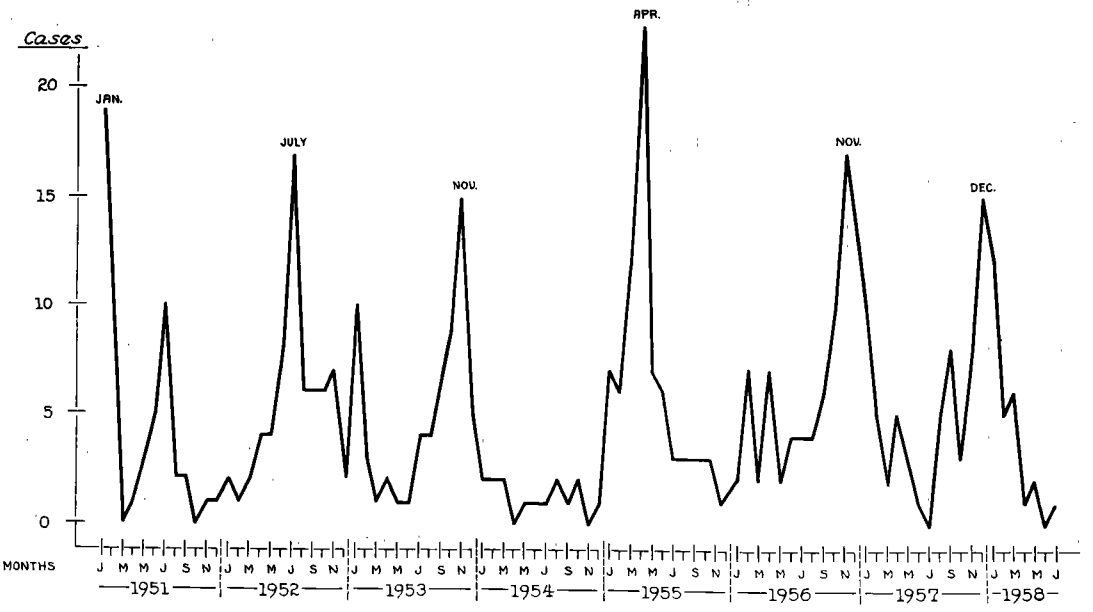


TABLE 6
AGE DISTRIBUTION OF PARALYTIC POLIOMYELITIS PATIENTS IN LÉOPOLDVILLE, 1951 THROUGH JULY 1958

Age (years)	Africans		
	No. of cases	Percentage of cases	Cumulative percentage
< 1	143	32.6	32.6
1-	203	46.2	78.8
2-	53	12.1	90.9
3-	13	3.0	93.9
4-	5	1.1	95.0
5-9	9	2.0	97.0
10-19	5	1.1	98.1
20-29	2	0.5	98.6
31-40	—	—	98.6
> 40	—	—	98.6
Unknown	6	1.4	100.0
Total	439	100.0	100.0

Age (years)	Europeans		
	No. of cases	Percentage of cases	Cumulative percentage
< 1	2	5.3	5.3
1-	4	10.5	15.8
2-	6	15.8	31.6
3-	1	2.6	34.2
4-	2	5.3	39.5
5-9	5	13.1	52.6
10-19	1	2.6	55.2
20-29	10	26.3	81.5
31-40	5	13.2	94.7
> 40	2	5.3	100.0
Unknown	—	—	100.0
Total	38	100.0	100.0

an important factor. The Institut d'Hygiène Marcel Wanson [1] maintains a large entomological service which seeks to keep down the populations of flies and mosquitos. Data collected since 1953 do not show any correlation of variations in fly abundance with the varying incidence of poliomyelitis (Cerf & Lebrun—unpublished information, 1959).

The age distribution of paralytic poliomyelitis cases differs markedly between the African and European populations, as shown in Table 6. Among Africans, 95% of the victims were under five years of age and 93.9% were under 3 years, whereas among Europeans only 39.5% were less than 5 years old.

TABLE 7
VIRUS ISOLATIONS FROM STOOLS OF HEALTHY AFRICAN CHILDREN BELOW 2 YEARS OF AGE IN LÉOPOLDVILLE; OCTOBER 1957 TO SEPTEMBER 1958 [a]

Agents isolated [b]	No. of positive stools (N = 1222)	Percentage of 1222 stools positive
Poliovirus	99	8.1
Type 1	25	2.0
Type 2	17	1.4
Type 3	57	4.7
Coxsackie	175	14.3
Type A	118	9.7
Type B	57	4.7
Adenovirus	72	5.9
ECHO	31	2.5
Unidentified	76	6.2
All agents	452	36.9

[a] Summary of more complete data from M. Vandeputte; see page 313 of this issue.
[b] In HeLa cell and human amnion cell tissue cultures and suckling mice.

Since October 1957 a virology section of the Institut de Médecine tropicale Princesse Astrid has been in operation. Prior to the commencement of the vaccination campaign in August 1958, the virology section had handled few specimens from paralytic cases. However, from October 1957 through September 1958 Dr M. Vandeputte had studied enteric viruses isolated from the faeces of healthy African children. Some of the results of these studies [1] are presented in Table 7 with Dr Vandeputte's kind permission. During each of the twelve months of the study period, approximately

[1] This is a laboratory for epidemiological studies of the local problems of public health. A branch of it, the City Health Service, is responsible for public health services. The combined staff of the Institute and the City Health Service consist of 4 physicians, 17 sanitarians, 6 European nurses, 42 African medical auxiliaries and 1260 workers distributed throughout the city.

[1] Reported in the article by Dr Vandeputte on page 313 of this issue.

100 stool specimens were collected from healthy African children younger than 2 years of age. Of these approximately 1200 faecal samples, 36.9% yielded cytopathogenic agents. Approximately 14% of the agents were identified as Coxsackie A or B viruses, while polioviruses (of all three types) and adenoviruses comprised approximately 8% and 6% respectively of the total. ECHO viruses were isolated from 2.5%, and 6% of the stools yielded unidentified agents. There was an epidemic of infection by type 3 poliomyelitis virus at the end of 1957, which corresponds to a peak of poliomyelitis incidence (see Fig. 2) and was reflected by the results of the serological studies (see the article by Plotkin et al. on page 215). However, all three of the polioviruses recovered from patients at that time were type 1.

PLAN OF THE FIELD TRIAL OF POLIOMYELITIS VACCINE

Because paralytic poliomyelitis among Africans in Léopoldville is almost limited to children below the age of 5 years (see Table 6), it was decided to limit the administration of the live virus vaccine to children below that age.

Administration

The vaccine was administered in 1-ml doses by means of a semi-automatic syringe. The ball of the syringe was placed in the bottle containing vaccine and vaccine was sucked through a rubber tube into the barrel of the syringe. Each pressure on the piston then delivered 1 ml. An attempt was made to squirt the vaccine into the back of the child's throat so that swallowing was involuntary. If the material was not swallowed, a second dose was administered. For children under 30 days of age, the dropper bottle was used and the 1-ml dose was delivered by dropping into the child's mouth.

Vaccination centres

As will be described in detail in the following communication (see page 215), for the first three months of the trial vaccination was done by district so as to permit better surveillance of the effects of vaccination. Subsequently, vaccination was performed in all districts simultaneously. Vaccination was started on 18 August 1958 and continues at present (January, 1960). The vaccination team includes one physician, two nurses, two clerks, and two assistants. Vaccination was performed at three types of centre. The first type, used frequently during the initial phases of the campaign, was the community centre, school, or dispensary. With vaccination at centres such as these, the population was called street by street by the administrative authorities the day before vaccination. The second type of vaccination site was the well-baby clinics. In these clinics, vaccination was included among the other paediatric procedures. The third category of vaccination centre consists of the Medical Census Centre.[1] At this Centre, children from all over Léopoldville coming for their annual health examinations were given live-virus poliomyelitis vaccine.

Blood specimens

Blood specimens for serological study were necessary for two general purposes. First, it was essential to an evaluation of safety that estimates be made of the numbers of children fed the vaccine who had been susceptible to poliovirus type 1 and susceptible to all three types at the time of feeding. By means of a serological survey the age-specific percentages of children without neutralizing antibodies against type 1 and against all three types could be determined, and these percentages, when applied to the age-specific numbers of children fed the vaccine, would provide these estimates.

Because the serological status of a population with respect to the polioviruses is constantly changing, it was necessary to conduct the blood collection programme at the time when vaccinations were started. Therefore, it was necessary to decide in advance the number of specimens needed to make a reliable estimate of seronegativity. The results of a small sero-survey in Léopoldville (Pattyn et al., 1957) had shown that poliovirus infections occur frequently and at an early age in that city. A crude calculation based on anticipated age-specific percentages in such a population indicated that approximately 1000 sera, if optimally allocated among the years of age below 5, would suffice to provide, with reasonable confidence, the percentages of triple-negatives and type-1 negatives in this population of children. The optimal allocation of 1000 specimens among approximately 75 000 children equally divided into five age-groups with the assumed

[1] By law, every person in Léopoldville is required to report once a year at the Medical Census Centre—operated by the Wanson Institute—to be examined and to obtain a certificate that he is not suffering from sleeping sickness, tuberculosis, leprosy or venereal disease. Each person is vaccinated against smallpox at this annual examination. This examination also provides an opportunity to collect the demographic statistics, which are estimated to cover more than 95% of those actually living in the city.

percentages of sero-positivity indicated is given in Table 8. On the basis of these numbers, the standard error of the expected mean number of triple-negatives (16 815) is 615, giving a 95 % sampling interval of 15 585 to 18 045. In other words, if these or similar percentages positive were found in the serological survey, the number of triple-negative children in Léopoldville could reasonably be estimated to fall within that range. The number of type-1 negatives would be very considerably greater. In practice, in order to avoid confusion with maternally derived, passive antibody, only children 6 months of age or older were selected to represent the age-group under 1 year.

The second purpose to be served by the collection of blood samples was to estimate the percentage of serological conversion among type-1-susceptible children. If the vaccine produced sero-conversion in 85 % of such children, 567 paired specimens would be necessary to state with 95 % confidence and within 3 % accuracy that this had resulted. On the basis of the anticipated percentages positive and the sample size for optimal allocation, both given in Table 8, the collection of 1000 such specimens would provide 653 type-1 negatives. In order to provide a somewhat greater margin of safety, since many children might not be available for re-bleeding, the sample size goal was increased in each age category, as indicated in Table 8. The number of specimens actually obtained in the basic serological survey is also reported in the same table.

Spread of attenuated virus from a vaccinated child to its contacts has been amply demonstrated (Gelfand et al., 1959; Paul et al., 1959).

In an effort to obtain some information on the extent of spread of attenuated virus during the trial in Léopoldville, 132 of the subjects from whom blood was obtained were not given vaccine, but were designated for re-bleeding as non-vaccinated controls.

It was originally planned to re-bleed the type-1 negative children after two months. However, delays in the laboratory postponed the re-bleeding until three months after the pre-vaccination specimen. Thus, the pre-vaccination specimens were obtained in August-November 1958 while the post-vaccination specimens were obtained from November 1958 to January 1959. Civil disturbances in early January 1959 supervened, so that we were unable to perform as many re-bleedings as had been planned; only 340 infants and children negative to type 1 poliovirus before vaccination were bled again. Some 62 children bled but unvaccinated were re-bled in January 1959.

Post-vaccination health inquiries

In order to obtain data relative to the freedom from side-effects of the CHAT strain, a system of post-vaccination health inquiries was devised. Two full-time public health nurses were stationed at vaccination centres during the early stages of the vaccination campaign, and approximately one out of every five children was selected for follow-up investigation. A card was filled out for each child selected, containing his and his parents' names, his address, age and sex, and the number of his siblings. In addition, information concerning the health of the child during the week before vaccination was

TABLE 8

METHOD OF ESTIMATION OF OPTIMAL NUMBER OF SERUM SPECIMENS NECESSARY FROM EACH AGE-GROUP FOR STUDY OF VACCINATION

Age (years)	Approximate population	Assumed % positive to each type	Expected % triple negative	Expected No. triple negative	Sample size for optimal allocation	Sample size goal in practice	No. of specimens obtained
1	15 000	10	72.9	10 950	340	400	411
1-	15 000	30	31.3	4 650	358	400	615
2-	15 000	60	6.4	900	168	200	199
3-	15 000	75	1.6	300	109	150	52
4-	15 000	90	0.1	15	25	50	41
Totals	75 000	—	—	16 815	1 000	1 200	1 318

recorded on the card. It should be noted that children who were actively ill at the time of vaccination were not vaccinated and therefore were not included among the group from which post-vaccination inquiries were made.

The children were seen by one of the nurses at home eight days after vaccination and their mothers were questioned concerning the child's health during the previous week. The information thus obtained was then recorded on the same record card. This process was repeated fifteen days after vaccination. Later visits were made in some cases to ascertain the outcome of an illness found at the visit on the fifteenth day. The recording of illnesses was made in general systemic categories: skin and mucosal, respiratory, digestive, urogenital, musculo-skeletal, and neurological. Special attention was paid to such symptoms as fever, vomiting, headache, and stiff neck. An attempt was made to indicate the severity of the illness by the designations "mild" (barely noticeable), "moderate" (definitely sick), and "severe" (indicated for hospitalization). In the event of a neurological illness, full details were recorded on the record card, and, if indicated, the child was referred to a physician for examination and diagnosis. The absence of illness was indicated by the statement that the child was well.

Surveillance of poliomyelitis during the vaccine field trial

A meeting of all of the physicians in Léopoldville was convened to inform them of the trial. They were asked to report every suspected case of poliomyelitis immediately and to give complete information as follows: name of the patient, age, sex, date of onset, date of vaccination if any, and the clinical symptoms. Wherever possible blood and faecal samples and cerebrospinal fluid were to be collected for examination at the Wistar Institute. Inasmuch as nearly all the physicians in Léopoldville have been practising in this area for some time and are familiar with the symptoms and signs of paralytic poliomyelitis, the sensitization of the physicians by the publicity attendant on the vaccination campaign probably increased to its maximal efficiency the completeness of reporting of poliomyelitis in Léopoldville.

Illness records

In summary, three types of health records were kept during the vaccination campaign:

(1) Serially numbered health inquiry cards. These were tabulated by a combination of machine and hand analysis.

(2) Records of bleeding, indicating the name, age, sex, and place of residence of the child from whom the specimen was collected.

(3) Detailed records of reported poliomyelitis cases which reported the name, age, sex, date of onset, date of reporting, clinical localization of lesions, date of vaccination if any, number of siblings in the family and whether or not vaccinated, and the dates of the specimens obtained from each patient.

ACKNOWLEDGEMENTS

The authors wish to express their appreciation to Dr C. Dricot, Médecin en Chef, Directeur Général des Services médicaux du Congo belge et du Ruanda-Urundi, and to Dr W. P. Bervoets, Médecin Inspecteur des Services d'Hygiène, for their helpful advice and administrative co-operation during this trial. We also wish to acknowledge the hard work of Dr Herman, Mlle H. Kint, and Mme Page in the daily control of vaccination.

RÉSUMÉ

La poliomyélite paralytique est endémique à Léopoldville (Congo belge). Depuis 1951, il y a eu, en moyenne, 63 cas nouveaux chaque année, et un taux de 19,4 cas pour 100 000 habitants. Plus de 80% des cas se sont produits chez des enfants africains de moins de trois ans. En conséquence, un plan de vaccination des nourrissons et des enfants africains contre la poliomyélite a été élaboré et exécuté. Léopoldville compte 350 000 habitants et possède des installations médicales modernes, notamment un institut de santé publique.

Les essais de vaccination ont été entrepris en août 1958, avec le vaccin atténué CHAT, de type 1 (Koprowski).

L'opération a été réalisée dans des dispensaires médicaux ou des cliniques spécialisées. Le vaccin a été administré par voie orale, en introduisant le virus au moyen d'une seringue dans l'arrière-bouche. Pour les nourrissons on a utilisé un compte-goutte. L'innocuité du vaccin a été contrôlée par des visites d'un grand nombre d'enfants à domicile, une ou deux semaines après administration du vaccin. Des échantillons de sang ont été prélevés avant et après l'ingestion du virus, afin de déterminer la sensibilité initiale de la population et sa réaction à la vaccination par le virus vivant. Cet article décrit les diverses opérations et l'organisation générale des vaccinations. (Les résultats de la vaccination sont présentés à la page 215 de ce numéro.)

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