Public Health Section

USE OF D.D.T. AS A PLAGUE CONTROL MEASURE IN THE BOMBAY STATE*

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PROPERTIES of D.D.T. as a powerful insecticide and its potent residual effect being well known, its use as a valuable measure in carrying out disinfestation of fleas with a view to controlling and preventing the spread of plague was considered worthy of extensive field trials. Until 1947, in the affected villages cyanogas fumigation of burrows and also total cyanogas fumigation of infected houses and mass inoculation were resorted to as routine anti-plague measures during an epidemic outbreak, and mass rat baiting with barium carbonate was undertaken as an inter-epidemic measure. However, experience suggested that these measures in the field were able to achieve only a partial control of plague infection which continued to reappear in such village during the favourable plague season.

The use of D.D.T. seems to have changed this state of affairs as observed from the recent field experience in various districts of the province. With a view to finding out the most effective method of using D.D.T. for plague control as also for its total eradication from an area, certain field trials were carried out, the results of which are given below :

Materials and methods

(*a*) One lb. of 50 per cent D.D.T. wettable powder was mixed with 5 gallons of water to make 1 per cent watery suspension sufficient for 3 to 4 houses or 5 hutments. This was used for indoor spraying of houses and huts at the rate of about 640 to 680 sq. ft. per gallon of suspension or 65 to 70 mg. of D.D.T. per sq. ft.

(*b*) Alternatively when D.D.T. technical became available, a 3 per cent D.D.T. oil emulsion at the rate of one gallon per about 2,000 sq. ft. was used, equivalent to about 70 mg. per sq. ft. of surface.

(*c*) Ten per cent D.D.T. powder was used for insufflation of burrows at the rate of one lb. per 100 burrows.

The spraying of the houses with D.D.T. was carried out by spray pumps worked by a gang of 'mazdoors' two per pump under the direct supervision of trained Sanitary Inspectors. The work was checked by the District Health Officers of respective districts or by Medical Officer, Plague Organization, and also by us from time to time through periodical visits to the infected villages. Floors and walls up to a height of four feet of houses were sprayed but in case of village huts the floors, complete walls and ceilings were sprayed. Burrows were insufflated with the same type of pumps as those used for cyanogas fumigation but in this case the mouths of the burrows were kept open and not sealed off with mud as is done in case of cyanogas fumigation.

Areas of operations

In 1947, preliminary observations were carried out in the plague-affected villages of Poona and Belgaum Districts. Observations were continued on a large scale during 1949 in the two districts of Satara North and West Khandesh which were badly affected with plague during that year as well as in a few villages in Belgaum and Dharwar Districts where the infection was sporadic.

In all, in 105 villages and 2 towns (Pop. 116,114) reporting human plague, 29 villages with rat fall (Pop. 19,756) and 46 threatened villages (Pop. 36,504) in 5 districts, D.D.T. treatment by various methods was carried out.

Staff engaged and cost involved

As the district health staff as well as the staff of the Plague Organization were jointly carrying out measures, data relating to the staff exclusively for this work are not available. However, it may be stated that for a village of 1,000 population a labour staff of one *mukadam* and 7 mazdoors working 3 spray pumps at the rate of 2 mazdoors per pump and one for moving equipment will complete the spraying of the whole village in 2 days' time and will require about 75 lb. of 50 per cent wettable D.D.T. powder or about 38 lb. of technical D.D.T.

Approximate cost for spraying the whole village of 1,000 population was, on an average, ranged from Rs. 350 to 400 for labour and materials. This excludes the cost of supervising staff of sanitary inspectors, medical officers, the entomologist and also of special transport equipment of motor trucks provided for the purpose. The various methods used in the treatment of village with D.D.T. in addition to a single dose mass anti-plague inoculation of the infected and threatened villages were :

* *Editorial note.*—Revised and rearranged in the Editorial Office by the referee, S. C. S.

Treatment I.—Indoor residual spraying of all houses and huts with 10 per cent watery suspension or 3 per cent oil emulsion of D.D.T., average dose 65 to 75 mg. per sq. ft. This operation was carried out in 152 villages of which 81 reported human plague cases, 27 only rat falls and 44 were threatened due to plague cases in the neighbouring villages.

Treatment II.—Combined method of D.D.T. indoor spraying of all houses and insufflation of burrows in the whole village with 10 per cent D.D.T. powder. Only 18 villages were included under this operation.

Treatment III.—Combined method of indoor residual spraying of D.D.T. in the houses of the infected locality only and insufflation of burrows of the whole village with 10 per cent D.D.T. powder. Only 7 villages reporting human plague cases were placed under this treatment.

Treatment IV.—Only insufflation of the burrows in the whole village. This treatment was given in only three villages reporting rat falls or considered threatened.

Results

The results in table I show that if an initial period of 72 hours after D.D.T. spraying is allowed to account for infection in persons who might have been in the incubation period of plague infection, there were 28 attacks and 2 deaths in case of treatment I, only 2 attacks and no death in case of treatment II, 4 attacks and no death in case of treatment III and 13 attacks and 2 deaths in case of treatment IV. Translated into rate of incidence per 1,000 population the figures were 0.4 (approx.), 0.14, 0.16 and 8.0 respectively. In the case of treatment I, however, out of 28 cases 9 occurred during a period between 10 days and 1½ months after D.D.T. indoor spraying, among the evacuated persons living in the scattered newly erected huts in two villages which escaped D.D.T. spraying.

Other results of D.D.T. treatment

(1) In one town there were a few plague cases in one locality, *viz,* 3 attacks and 2 deaths, the plague infection stopped completely after treatment III. In the other infected villages as treated by this latter method infection continued to occur in the non-sprayed areas and hence all houses in the villages were sprayed to stop the infection.

(2) In one village, on the outbreak of plague, burrows in all the houses in the village were insufflated with 10 per cent D.D.T. powder and only plague-infected houses were sprayed with 1 per cent water suspension of D.D.T. As plague attacks were still occurring in the whole village again all burrows were again insufflated

TABLE I

Effects of various treatments of D.D.T. indoor spraying and insufflation of rat burrows on the incidence of plague in different villages in the four districts of Bombay State

Method of treatment	Number of villages treated	Reporting	Total population	Before D.D.T.		Reporting of plague attacks and deaths after D.D.T. treatment						Total		Number of villages with number of plague after D.D.T.
						Within 3 days			Between 3 and 10 days			After 10 days					
				A	D	Number of villages	A	D	Number of villages	A	D	Number of villages	A	D	Villages	A	D	
I(*a*)	81	Human plague.	71,053	588	242	9	45	9	3	19	2	3	9	0	15	73	11	66
(*b*)	27	Rat fall	19,750	0	0	0	0	0	0	0	0	0	0	0	0	0	0	27
(*c*)	44	Threatened	36,504	0	0	0	0	0	0	0	0	0	0	0	0	0	0	44
II	18	Human plague.	14,348	91	25	4	7	1	2	2	0	0	0	0	6	9	1	12
III	7	Do.	24,642	77	34	1	2	0	1	2	0	1*	2	0	3	6	0	4
IV	3	Rat fall	1,633	0	0	..	..	..	..	..	..	..	..	..	3	13	2	..

*Cowdung applied to walls some 3 to 7 days after D.D.T. spraying.

A = attack; D = death.

and the affected locality sprayed. Infection still continued to occur and the whole village was sprayed with 5 per cent D.D.T. in oil at the rate of one quart for 2,000 sq. ft. or 50 mg. per sq. ft. Thereafter 7 attacks and 1 death occurred within the first 3 days and 13 attacks and 1 death between the 4th and 10th day and 3 attacks and no death between the 11th and 30th day after complete spraying. In this case 50 mg. per sq. ft. of D.D.T. was considered inadequate for rapid disinfestation of fleas.

The results of different D.D.T. treatments on flea indices are given in table II.

TABLE II

Effects of D.D.T. treatments on the flea indices of different villages at various intervals after the treatment

Methods of treatment	Village	Before treatment	Flea indices						
			Intervals after treatment						
			7 days	10 days	15 days	1 month	2 months	3 months	5 months
I	1	3.6	..	..	0.0	..	..	0.0	..
	2	8.0	..	4.0	..	0.4	..	..	..
	3	8.4	..	..	..	0.8	..	..	..
	4	6.6	..	..	..	..	0.0	..	..
	5	4.75	..	..	1.0	..	..	..	..
	6	7.6	0.6	..	..	..	..	..	..
	7	9.7	2.2	..	0.5	..	..	..	..
	8	2.42	..	0.47	..	..	..	..	0.45
II	1	3.0	..	..	..	0.15	..	0.0	..
	2	4.42	..	0.42	..	..	..	..	..
	3	3.51	..	..	0.07	..	..	..	0.6
	4	6.84	..	1.39	..	..	0.25	..	..
	5	2.0	0.0	..	..	..	0.77	..	..
IV	1	17.1	..	2.8	..	..	..	..	..
	2	8.3	..	3.08	..	..	..	0.2	..
	3	1.7	..	..	..	..	..	..	1.4
	4	2.0	..	..	..	..	..	0.26	1.2
	5	..	..	..	..	..	0.2	..	..

Discussion and recommendations

It will be seen from the tables that the method of indoor residual D.D.T. spraying of all houses in a village and the combined method of indoor residual spraying of the whole village with insufflation of burrows in and around all houses in a village have both given equally effective results as regards control of plague infection. Similarly by both the methods the flea index is reduced significantly below the critical level of one and thus rapid disinfestation is achieved in about 10 days' time after completion of D.D.T. treatment. Thus there seems to be no need for doing insufflation of burrows with 10 per cent D.D.T. powder for control of plague infection. Indoor residual spraying of all houses by itself alone can be depended upon to achieve it. Only other anti-plague measure in addition to D.D.T. treatment carried out in all infected villages was mass inoculation with a single dose of Haffkine* plague vaccine. About 40 per cent of the population was thus protected. Other methods of D.D.T. treatment as given in table I are uncertain for efficient and prompt control of plague infection.

By treatment I, the infection in the villages stopped completely in almost all cases in about 8 to 10 days' time after completion of spraying of the whole village. This experience was completely in contrast with our previous experience of control methods with cyanogas fumigation both as regards rapidity and certainty in achieving an effective control of human plague infection. The chain of rat-flea-man cycle of infection appears to be broken effectively and continuously for some time, leading to a profound reduction in quantum of infection in the villages. The records of flea indices and of human cases in the infected villages after D.D.T. spraying of the whole village indicate that it takes about 7 to 10 days in the field to effect destruction of most fleas in the majority of houses in a village. Delay in immediate completion of the spraying of all houses in a village entailed a positive risk in prolonging infection in some villages. In such cases there was also a greater

*Haffkine Institute vaccine would be a better designation. The present vaccine was developed by General Sir Sahib S. Sokhey, and has little to do with the original vaccine made by Haffkine.—EDITOR, *I.M.G.*

possibility of spread to other neighbouring villages.

It may be noted that Satara, Belgaum and Dharwar Districts have been described to form one of the endemic centres of plague in Southern India. After 1949 epidemic, inter-epidemic measures by insufflation of burrows with 10 per cent D.D.T. powder were carried out in all affected villages in West Khandesh District. In Satara, Belgaum and Dharwar Districts, this could not be done. Even then it was observed that during 1950 and 1951 (and up to the end of January 1952) there was no recrudescence of plague infection in any of the villages in the above districts (except one village in West Khandesh District) affected in 1949 and sprayed with D.D.T. Thus observations in the field as stated above suggest that there is no necessity for carrying out insufflation of burrows as an inter-epidemic measure and also during plague epidemic. There seems to be no need for any rat destruction campaign either, during the epidemic or inter-epidemic period. The reason for this is that D.D.T. spraying through its residual effect appears to be able to achieve a maximum flea reduction* on most of the house rats in a village provided the spraying is properly carried out without omitting any huts or other structures.

There were a few villages where recrudescence or reinfection of plague occurred 6 weeks to 2 months after D.D.T. spraying of the whole village which was speedily controlled by the second round of spraying of the villages.

Instances and reasons where D.D.T. failed

In certain villages even though all the houses and huts and other structures in the village were sprayed with D.D.T., plague cases continued to occur after 10 days of spraying and continued up to a month or more. Personal investigations carried out by one of us (T. B. P.) indicated the following drawbacks :—

(1) In certain villages people after the houses were sprayed with D.D.T. applied cowdung or mud-wash to the walls and floor from 2 to 4 days after spraying and thus reduced the effective concentration of D.D.T. on the walls and floors leading to continuation of plague infection.

(2) In another instance in a village in Belgaum District, infection continued to occur after D.D.T. spraying up to a period of one month which was attributed to low dosage (50 mg. per sq. ft.) of D.D.T.

(3) In another group of villages where infection continued to occur after 10 days from D.D.T. spraying up to a period of a month or so, it was found that while the D.D.T. spraying of the village was undertaken or sometimes even before that, the village people had either partially or wholly evacuated in the fields on the outskirt of the village. Here, infection continued to occur in the evacuated huts indicating that many fleas had escaped the fatal contact with D.D.T. Even when huts are sprayed infection may continue to occur, as villagers mostly sleep in the open, outside the huts and their personal effects are also sometimes stacked outside the huts and hence may escape contact with D.D.T. sprayed surface.

Obvious remedy in such instances is to have a control evacuation, so that all personal effects can be treated with D.D.T. before removal in addition to treating the evacuated huts well in advance of occupation.

In exceptional cases where due to some faulty methods of spraying, low dosage or other reason, there is recrudescence or reinfection in the village, it can be promptly and effectively terminated by second round of spraying of the whole village.

An important point of note was that where the work of D.D.T. spraying was taken up after the report of human cases, there was time for the infection to spread to neighbouring villages by transference of infected rats or fleas through the personal effects of villagers going out from the infected villages as also in the transport of goods.

To check this spread of plague from an infected village to adjoining ones, it is considered essential to tackle the village immediately on the report of rat fall and if human cases are reported, to take up the infected and surrounding villages simultaneously. This is of vital importance in case of new areas getting infected for the first time and thus having a new nidus of infection getting implanted.

It is an established fact that in a plague-infected village after the prevalence of a severe plague epizootic among rats, resistant breed of rats possessing a high immunity against further plague infection survive. Advantage of D.D.T. spraying is that it avoids large killing of rats and thereby the resistant breed of rats is not destroyed as happens with cyanogas fumigation, where probably the large scale killing of resistant breed of rats may be a factor in the continuation of plague epidemic in the next season.

Summary and conclusions

(1) Effects of single or combination of methods of D.D.T. spraying were studied in two towns and 180 villages of which 106 reported human plague cases, 30 reported rat fall and 44 were threatened.

(2) D.D.T. when used as an indoor residual spray alone is found to be effective in rapidly bringing down and controlling human plague infection within 7 to 10 days after spraying, if carried out thoroughly and promptly. The only other measure carried out was a single dose

*This has already been brought out by previous workers. See References under Editorial on 'Plague in Calcutta', 1948, *I.M.G.*, **83**, 137.—EDITOR, *I.M.G.*

mass inoculation of about 40 per cent of the population with Haffkine plague vaccine.

(3) Flea index was also reduced markedly in sprayed villages in about 7 to 10 days' time after spraying and remained so for 2 months or more.

(4) Experience of four years of anti-plague measures in the field on a large scale indicate that the rat destruction as an anti-plague measure either during the inter-epidemic or epidemic period is not necessary and can be safely discarded. Insufflation of burrows with 10 per cent D.D.T. powder as an anti-plague measure during epidemic is also not considered necessary.

DIRECTORATE-GENERAL OF HEALTH SERVICES, NEW DELHI

WHO/UNICEF Assisted BCG Vaccination Campaign

MONTHLY REPORT FOR JANUARY 1952

State	Personnel*		Tested	Completing test	Positives	Negatives	Vaccinated	Remarks
	Doctors	Technicians						
1	2	3	4	5	6	7	8	9
Part A States								
Assam	1	1	2,592	1,878	828	1,050	1,050	Campaign in Tea Estates, Assam, completed in December 1951. Hence no figures this month. Jamshedpur figures only.
Bihar	3	3	745	630	418	212	212	
Bombay ..	10	14	16,736	15,329	10,852	4,477	4,410	
Madhya Pradesh ..	4	4	8,357	7,254	3,722	3,532	3,436	
Madras ..	3	3	2,454	2,140	1,474	666	408	
Orissa	3	4	8,035	4,090	2,724	1,366	1,362	
Punjab ..	12	30	69,784	49,890	28,570	21,320	21,220	
U.P.	8	35	58,233	43,866	28,674	15,192	15,142	
West Bengal ..	13	20	22,804	18,775	9,915	8,860	8,770	
Part B States								
Hyderabad ..	2	3	11,167	8,549	5,181	3,368	3,341	
Kashmir ..	2	7	8,900	7,512	3,938	3,574	3,567	
Madhya Bharat ..	5	27	32,807	17,616	9,825	7,791	7,762	
Mysore	1	1	8	8	3	5	5	
Pepsu	3	3	3,012	2,736	1,649	1,087	1,087	
Rajasthan ..	1	2	1,126	940	552	388	371	
Saurashtra ..	1	9	8,205	6,565	2,988	3,577	3,577	
Travancore-Cochin	4	18	7,816	6,574	3,524	3,050	3,001	
Part C States								
Delhi	2	2	6,194	3,678	2,163	1,515	1,498	
Kutch	Figures not received.							
Vindhya Pradesh	1	1	1,096	659	382	277	277	
TOTAL ..	79	187	270,071	198,689	117,382	81,307	80,496	

*Personnel of reporting teams only are given.

Supplement for December 1951

Bihar	713	713	668	45	45
Kutch ..	790	778	361	417	412
TOTAL ..	1,503	1,491	1,029	462	457

Supplement for November 1951

Hyderabad ..	1,494	1,321	534	787	786
Kutch	1,725	1,576	730	846	835
TOTAL ..	3,219	2,897	1,264	1,633	1,621

Supplement for October 1951

Kutch	545	494	193	301	286
GRAND TOTAL ..	5,967	4,882	2,486	2,396	2,364