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EXPERT COMMITTEE ON PLAGUE

Report on the First Session

Geneva, 19-24 September 1949

	Page
1. Election of chairman	3
2. Adoption of agenda	3
3. Suggestions for future WHO action in the field	3
4. Determination of endemic areas	5
5. Plague therapeutics	7
6. Elimination of reservoirs and vectors of plague in sea- and airports	8
7. Physiology of the flea	10
8. Plague-control organization for national health-administrations	10
9. Manual on plague	10
Annex 1. Eradication of plague from endemic areas	11
Annex 2. Wild-rodent survey of African territories	15
Annex 3. Outline of plague-control field work	16
Annex 4. Classification of human cases of plague, based on clinical, epidemiological, and laboratory data	31

WORLD HEALTH ORGANIZATION

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GENEVA

OCTOBER 1950

EXPERT COMMITTEE ON PLAGUE

First Session

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The report on the first session of this committee was originally issued in
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EXPERT COMMITTEE ON PLAGUE

Report on the First Session¹

The first session of the Expert Committee on Plague of the World Health Organization took place in Geneva from 19 to 24 September 1949.

1. Election of Chairman

Sir Sahib Singh Sokhey was unanimously elected Chairman, Dr G. Blanc was elected Vice-Chairman, and Dr P. C. C. Garnham, Rapporteur.

2. Adoption of Agenda

The provisional agenda was adopted without alteration.

3. Suggestions for Future WHO Action in the Field

3.1 *The WHO team and its composition*

The committee welcomed the decision of the Second World Health Assembly² to take an active part in the eradication of plague in areas where it is still a serious health hazard and an ever present menace to the rest of the world.

The committee recommended that a WHO team of experts should be formed to work in selected areas in collaboration with local teams provided

¹ The Executive Board, at its fifth session, adopted the following resolution:
The Executive Board

(1) NOTES the report of the Expert Committee on Plague on its first session, and
(2) AUTHORIZES its publication;

Taking into account the recommendations of the expert committee in considering relevant items on its agenda,

(3) TRANSMITS the report to the Third World Health Assembly;

(4) POINTS OUT that recommendations of expert committees which concern WHO policy and operations remain recommendations unless and until they are implemented by the Executive Board or the World Health Assembly in adopting and putting into action the annual programme of WHO;

(*Off. Rec. World Hlth Org.* 25, 5)

² *Off. Rec. World Hlth Org.* 21, 180

by the national government. These local teams should be sufficiently strong and have enough qualified personnel to carry out research work and surveys as well as to conduct the campaign planned in collaboration with the WHO team. Such local teams should be capable of taking full charge of the programme when eventually the WHO team withdraws.

The WHO team would, in full co-operation with the local teams, study the problem of the locality, decide on the plan of work, and set in motion the investigations and the control programme. Once the WHO team was satisfied that the campaign was working smoothly, it would transfer its activities to another part of the world and set up the same sort of organization. The team, a member or members of it, at pre-arranged times, would return to the centres to inform themselves of progress made, re-organize if necessary, and institute special investigations to clear up problems encountered during the first part of the campaign. The team would remain in close touch with the selected centres so that in course of time the team would become thoroughly acquainted with the conditions under which plague occurs throughout the world. The team would be able to integrate the world's fund of knowledge and enrich it by its own contribution.

The WHO team would steadily raise the standard of control work by local teams to a uniformly high level of efficiency. To achieve worthwhile results, this association between the WHO team and the local teams would have to be maintained for a number of years. The epidemiology of plague is such that plague may break out in a locality and disappear, and appear again after a lapse of five or six years. In view of this, the work at each centre should be continued under close supervision and direction for five or six years, to permit scientific evaluation of the results. Such work, therefore, could not be carried out by temporary demonstration teams. What is desired is a team which will study, direct, and organize work over a period of years and thus help to put into practice WHO leadership in the field of eradication of plague.

The committee also feels that the mere application of suppressive measures will not be enough. This work will have to be backed up by improving the sanitary status of the areas concerned by well thought out and practical methods of improving housing, to break the association between rats and man.

Such a team would have to consist of men who have a deep understanding of the problems through their own plague work in the field. They will have to be of sufficient scientific standing to inspire confidence among the local teams and win the support of the governments of the countries concerned. They will, between them, possess a combined knowledge of epidemiology, bacteriology, entomology, mammalogy, and environmental sanitation.

The team would consist of :

- (1) a medical epidemiologist and bacteriologist
- (2) an entomologist
- (3) a zoologist-mammalogist
- (4) a sanitarian.

In addition, the committee feels that the senior scientific staff should have a permanent secretary-stenographer and a laboratory technician.

At least one member of the team should have medical qualifications.

Having noted Dr Macchiavello's paper on plague-control field work,³ the committee adopted it as a guide for organizing local field team work, but thought fit to recommend certain modifications to the section of personnel, which are shown in Appendix 3 to Annex 3.

3.2 *Suggested areas for work*

- (1) Bombay Province, India
- (2) One of the infected islands off the coast of Africa (Azores or Madagascar)
- (3) Morocco
- (4) Belgian Congo
- (5) China

the actual centres to be selected in consultation with the governments concerned, on the assurance that they will provide adequate local teams and laboratory facilities.

3.3 *Training*

The centres where the WHO team operates would be made into training centres.

4. **Determination of Endemic Areas**

4.1 *Definitions*

The committee agreed to the following definitions :

Definition of an endemic plague area. An area in which the domestic rodents and their ectoparasites form permanent reservoirs of plague due to favourable ecological conditions which permit perpetuation of infection and from which human infection arises.

Definition of a wild-rodent or sylvatic plague area. An area in which wild rodents and their ectoparasites form permanent reservoirs of plague due to favourable ecological conditions which permit perpetuation of infection.

³ See Annex 3, page 16.

The committee felt that there were large gaps in our knowledge of endemic areas. In many instances this was due to the fact that facilities for investigation and survey were not fully available to the local health-authorities. The committee recommended that national health-administrations of territories in which plague exists investigate, determine, and report more fully on the presence and extent of plague infection in their areas. WHO might give such technical assistance in the undertaking of this work by the local authorities as might be required and requested by the national health-administrations of the affected territories.

4.2 *Survey and delimitation methods*

The following information should be collected for the delimitation of plague areas, preferably presented in the form of tables, charts, and maps :

- (1) Geographical prevalence of human plague :
 - (a) plague morbidity and mortality,
 - (b) monthly and annual incidence for geographical units.
- (2) Geographical distribution of rodent plague.
- (3) Geographical distribution of the proved or potential reservoir hosts and of proved or potential flea vectors in relation to the endemic, enzootic, and plague-free areas.

4.3 *Wild-rodent survey of tropical Africa*

The committee considered the summary report on the second session of the Joint OIHP/WHO Study-Group on Plague,⁴ and Dr Garnham's proposal for a wild-rodent plague survey of tropical Africa.⁵ It felt that before any decision could be taken on the latter proposal, further information on the plague situation in the affected territories must be obtained. For this purpose it drew up a suggested questionnaire, which is attached as Annex 2.

4.4 *Nomenclature of plague reservoirs and vectors*

A report on the nomenclature of plague reservoirs and vectors was presented to the committee by Dr Macchiavello.⁶ The committee decided that when further information had been added with the assistance of the members of the committee a revised document should be issued for consideration at the next session.

⁴ *Off. Rec. World Hlth Org.* 19, 18

⁵ Unpublished working document WHO/Plague/6

⁶ Unpublished working document WHO/Plague/9

5. Plague Therapeutics

The committee was of opinion that further research on plague therapeutics was necessary and needed continued support and extension wherever possible.

The committee was familiar with the work already carried out in India and felt that that country possessed advantages, such as an adequate number of cases of the disease, institutions for the proper laboratory study of the infections, and trained personnel capable of undertaking therapeutic research. The committee therefore considered that the Government of India should be requested to continue to support projects of research in the chemotherapy of plague under the Indian Research Fund Association.

5.1 *Treatment of pneumonic plague with streptomycin and other antibiotics*

The committee discussed the treatment of pneumonic plague and considered that streptomycin was proving the best therapeutic agent at present. It could abort pneumonic plague with a dosage of 15 g. for a man of average weight.

The committee felt that there were suitable areas in South America and in China where a considerable number of pneumonic plague cases occur and where investigations on the efficacy in treatment of this and other antibiotics could profitably be undertaken.

5.2 *Prophylactic administration of sulfonamides or streptomycin*

The committee was of opinion that prophylactic administration of sulfonamides to pneumonic plague contacts was effective and recommended a dosage of 3 g. of sulfadiazine or sulfamerazine a day for a period of not less than five days after the last exposure to infection.

At the same time the committee considered that streptomycin was not to be recommended for prophylactic use because of its rapid excretion from the system and the difficulty of repeated administration.

The committee recommended that attention should be paid also to the possibility of using chemoprophylaxis for persons at risk in bubonic plague epidemics.

6. Elimination of Reservoirs and Vectors of Plague in Sea- and Airports

The committee considered the summary report on the second session of the Joint OIHP/WHO Study-Group on Plague⁷ and made some minor modifications to the recommendations contained therein. They recommended that the national health-administrations maintain permanent organizations to carry out plague control at sea- and airports, and described the control measures as under :

6.1 *Measures of protection for cities, sea- and airports*

- (i) Application of 5% DDT dusting powder every six months or at intervals compatible with the maintenance of a flea index under 2 ;
- (ii) systematic deratting with sodium fluoracetate (compound 1080) or other methods of rodent destruction ;
- (iii) protection of merchandise with 5% DDT dusting powder or other effective insecticides ;
- (iv) application of 5% DDT dusting powder to vehicles, in case of epizootic recrudescence within an enzootic area ;
- (v) rat-proofing of buildings and outbuildings.

Additional measures appropriate for airports include :

- (i) The maintenance of a clear zone within a radius of 200 metres around the airport buildings and the ground used for the parking of aircraft ;
- (ii) application of DDT to aircraft ;
- (iii) application of DDT before loading to merchandise coming from enzootic zones and which, in the judgement of the local health-authorities, might contain infected fleas ;
- (iv) inspection of aircraft in order to avoid transportation of rodents ;
- (v) in case of an epidemic in the enzootic zone : application of 5% DDT dusting powder to the garments and personal effects of the passengers coming from the infected zone, at port of departure.

6.2 *Recommendations as to length of period after which a port infected with plague may be declared free of infection*

The committee gave due regard to all the factors concerning the risk of infection following the occurrence of rat plague in a port

⁷ *Off. Rec. World Hlth Org.* 19, 18

and the efficacy of the new insecticides and rodenticides in control measures. It agreed that the present period of six months generally in use was far too long. The committee recommended that an infected port should be declared free one month after the disinfestation measures given above for ports have been intensively applied to the area and proved effective to the satisfaction of the national health-authorities.

6.3 *Application of rodenticides for deratting of ships*

The new rodenticides, such as compound 1080, offer simple and easily undertaken methods for the deratting of ships; complicated apparatus and specially trained personnel are not required for their use. In view of these facts, the committee considered that investigations as to the best methods of deratting, particularly using the new rodenticides, should be undertaken by all national quarantine and port authorities able to carry out such investigations. In the meantime, the committee considers that deratting with cyanogen-compound rodenticides should continue.

6.4 *Methods of disinfestation of rice and other cereals whether in bags or bulk*

The committee considered the report on the first session of the WHO Expert Committee on International Epidemiology and Quarantine,⁸ and a note on the disinfestation of rice presented by Dr R. Pollitzer.⁹ It was agreed that further investigation on this subject was necessary, and that the investigations should have reference to all food cereals and other materials capable of conveying infection, such as cotton, jute bags, hides, and skins. The committee was informed that investigations into this problem might possibly be undertaken by the Colonial Insecticides Committee of the British Colonial Office, and in some suitable institutes in India. The committee recommended that the governments of these countries be approached with a view to their undertaking this work.

The committee, having learnt that the Food and Agriculture Organization (FAO) was also investigating and developing methods of disinfestation and rodent control with a view to preventing loss of food grain during storage and transportation, recommended close collaboration with FAO and exchange of information in developing disinfestation measures.

⁸ *Off. Rec. World Hlth Org.* 19, 5

⁹ Unpublished working document WHO/Plague/8

7. Physiology of the Flea

In view of the fact that information on the physiology of the flea is meagre in the extreme, the committee recommended that research on this subject be undertaken at suitable institutes.

8. Plague-Control Organization for National Health-Administrations

The committee wished to stress that for effective control of plague in their territory the governments of plague-infected countries should establish a specialized plague-control service, if such were not already in operation.

9. Manual on Plague

The committee recommended that WHO consider the preparation and publication of an up-to-date manual on plague.

Annex 1**ERADICATION OF PLAGUE FROM ENDEMIC AREAS**

The following are the methods recommended for use in the control programme :

1. Epidemiology

Statistical information relative to :

- (1) human population
- (2) rodent population
- (3) species of ectoparasites

2. Ecological Surveys Relative to Rodent Populations

- (1) environmental conditions
- (2) climate — macro and micro climate
- (3) habitat and food sources
- (4) inter-relation of reservoirs and vectors with man

3. Detection of Plague Infection — Methods to be Employed**3.1 Human plague — criteria of diagnostic techniques**

- (1) clinical
- (2) epidemiological
- (3) laboratory

Note: The above classification is based on that adopted by the National Plague Service of Brazil.¹

The following new techniques for identification of *Pasteurella pestis* and allied organisms are recommended :

- (1) culture on agar at 28° C.
- (2) agglutination
- (3) use of specific phage
- (4) complement-fixation test in the diagnosis of recovered cases

¹ See Annex 4, page 31.

3.2 *Rodent plague*

Gross anatomical examination, inoculation of tissues (buboes, spleen, and marrow) by single or pool method. Use of penicillin for suppression of contaminants should be tried. Identification of micro-organisms isolated in culture by biochemical and serological tests.

3.2.1 *Shipping of specimens.* Tissue specimens — spleen, bubo, or bone — should be dispatched in sterile bottles. Agar method recommended. It consists of immersing the tissue piece into sulfite agar mass in a tube. Impregnation of agar mass with penicillin should be studied as a means of preventing the growth of secondary contaminant organisms.

3.2.2 *Laboratory examinations.* Inoculation of laboratory animals (guinea-pigs or white mice) should be followed by blood culture taken on the second day of inoculation. At autopsy, tissues are streaked on plain agar and incubated at 28° C. or on agar with sodium sulfite at 37° C.

Note: Diagnosis based solely on smears is not reliable.

3.3 *Ectoparasites*

3.3.1 *Collection.* The rats, collected in paper bags, are treated with cyanogas to kill rats and fleas, and fleas are put in a rubber-stoppered flask moistened with a few drops of water. Fleas from the burrows and other sites should be taken by suitable methods. In tropical countries, flea specimens should be dispatched with the addition of 2.5% saline. Whenever conditions permit, two samples should be sent, one for classification and another for inoculation. Specimens of fleas to be used for classification should be preserved in 70% alcohol with filter paper to prevent shaking of the specimen.

4. Control Methods

Newer methods of flea and domestic-rodent control have superseded the old ones.

4.1 *The use of insecticides*

The principal attack is directed against the fleas. This has been made possible through the development of effective insecticides with residual action (pulexides). DDT has invariably given effective results. Newer insecticides are being continually developed. They need investigation before they can be recommended.

4.2 *Rodenticides*

To obtain successful results, systematic application and distribution of rodenticides is an essential measure. The following rodenticides are effective :

4.2.1 *Sodium fluoracetate (compound 1080)*² is odourless, tasteless, highly soluble in water, possesses no repellent effect on rats, and repeated intake develops no tolerance. It may be used in an aqueous solution, in cakes, or as a coating on rolled oats or other suitable cereal in a concentration of 5 per 1,000. It should be used sparingly as a rule; not more than 7 to 10 baits per house. It is one of the most potent poisons and produces chain poisonings. No antidote is yet available. Stringent precautions are therefore necessary in its use and experienced personnel is required to handle it. Addition of colouring matter to the aqueous solution and the solid bait is imperative to favour its detection. Addition of a trace of vanilla essence may improve the acceptability.

4.2.2 *α-naphthyl-thiourea (ANTU)* has the disadvantage of being specific to *Rattus rattus norvegicus* only.

4.2.3 *Red squill*. Preparations standardized according to the methods developed by the United States Fish and Wild Life Service should be used.

4.2.4 *Zinc phosphide* as a good all round poison in cereal baits is a useful and effective rodenticide under conditions where more poisonous preparations cannot be used.

Intensive researches are in progress to discover new and better rodenticides. The group dicoumarin may be mentioned in this connexion.

4.3 *Poison gas. Cyano dust*

The committee recommends close collaboration with the WHO Expert Committee on Insecticides in obtaining fuller information on developments.

4.4 *Rat-proofing, harbourage elimination, and disposal of garbage*

4.5 *Immunization methods*

No method of immunization has eradicated plague. Immunization gives partial protection to human populations but does not touch the fundamental source of infection or destroy the reservoir.

² The Executive Board, at its fifth session, adopted the following resolution :
The Executive Board . . .

(5) DRAWS ATTENTION to the statements included in the annex to the report concerning the dangers inherent in the use of 1080 as a rodenticide.

(Off. Rec. World Hlth Org. 25 5)

Anti-plague vaccine. Immunity develops after use of killed antigen and live avirulent vaccines. In endemic areas where populations are heavily exposed one dose for prophylactic purposes has administrative and economic advantages. Methods of preserving the efficacy of the vaccine in a form convenient for extended transportation without refrigeration and of safe administration need to be developed.

Chemically-killed detoxicated growths of virulent plague bacilli in a liquid medium are used as vaccines (Haffkine Institute, Bombay).

4.6 *Measures concerning patients and contacts*

Segregation measures are disruptive to social life and are no longer recommended in view of the availability of residual insecticides and effective methods of chemoprophylaxis and treatment.

5. **Technique of Control**

The development of a sound organization is basic. This organization must be planned as follows :

5.1 *Administration*

5.2 *Laboratory, epidemiological, and intelligence unit*

5.3 *Field work*

A survey is essential before starting any field work in order to obtain information relative to plague incidence and rodent and flea distribution. Census baiting and standard flea-counts are used for estimating the rat and flea abundance. As a guide to future work the methods which have proved successful in South America should be followed and adapted to local conditions.

Annex 2

WILD-RODENT SURVEY OF AFRICAN TERRITORIES

Questionnaire to Governments

- (1) Date of last case of human plague in territory.
 - (2) Number of human cases per annum since 1935, giving monthly incidence.
 - (3) Date of last finding of rat plague.
 - (4) Number and species of domestic rats positive to plague since 1935, with total number examined, giving monthly incidence. Method of examination employed.
 - (5) Has plague in the wild rodents been observed in the territory?
If so, state :
 - (a) how diagnosed
 - (b) date of occurrence
 - (c) species of rodent
 - (d) association with human cases
 - (e) rodent mortality of any kind
 - (6) How does plague spread in the territory?
 - (7) Flea vector :
 - (a) identification of rodent fleas
 - (b) species incriminated as vector
 - (c) species suspected as vector
 - (8) Actual geographical location of infection. Map showing geographical location to be attached.
 - (9) Meteorological information on plague area since 1935.
 - (10) What methods of plague control are in routine use?
 - (11) Publications on the subject may be referred to.
-

Annex 3

OUTLINE OF PLAGUE-CONTROL FIELD WORK¹

The following outline of plague-control field work is based on experience acquired in Peru, South America, especially at Tumbes, Huacho, Lima, and Trujillo, from October 1945 to July 1949. The methods described have been used to control epidemic and endemic plague, as well as epizootics and enzootics, in urban and rural areas where these were prevalent in domestic rodents. They do not apply to wild-rodent plague, but have proved to be effective in controlling the secondary spread of sylvatic plague between humans. Plague-control demonstrations have been strongly supported by the Ministry of Public Health in Peru and by the Pan American Sanitary Bureau, and were financed by \$30,000 during the first three years of field work, through a grant-in-aid made by the Institute of Inter-American Affairs.

The main items of the programme were as follows :

(1) To establish new methods of plague control with the aid of the insecticides of residual action and of the powerful rodenticides then available.

(2) To train local personnel belonging to the Peruvian National Anti-plague Service in these new methods.

(3) To eradicate plague from endemic urban and rural areas where it had been prevalent for at least 40 years (Trujillo City and the valley of the River Moche).

(4) To prevent the re-infection of cities surrounded by rural plague (Huacho City in the valley of Huaura-Sayán).

(5) To eradicate plague in cities with increasing epidemics at the start of the plague season (Tumbes).

(6) To establish new methods of administration in plague control.

The areas affected by plague have been under the control of the national plague authorities since 1903 when the disease was first introduced in those areas. After 1930, the Pan American Sanitary Bureau undertook the permanent supervision of the local programme with the aid of several well-known specialists. Since then, some important work has been accomplished and new methods for the control of plague devised. The temporary results were mostly satisfactory, but the eradication of plague in some

¹ Submitted by Dr A. Macchiavello, Planning Officer, WHO Regional Office for the Eastern Mediterranean, Alexandria, Egypt.

resistant endemic foci proved difficult. There is no doubt, however, that a comparison between the temporary success obtained in the past and the permanent results obtained by the application of new methods shows the superiority of the latter in controlling plague, and, if used properly and continuously, in eradicating it from urban and rural areas affected by domestic-rodent plague.

The development of the programme was helped fundamentally by the existence of the following :

(1) A national antiplague organization with sufficient personnel and equipment.

(2) A chain of local laboratories, controlled by a central laboratory, which were reconstructed and re-equipped. Field laboratory facilities were available in every campaign.

(3) The carrying-out of personal epidemiological investigations for every plague area in the country, from December 1944 to July 1949, and establishment of a central epidemiological service with epidemiological information units attached to the central and local laboratories. The central file for epidemiological and bacteriological data and for positive plague cases (humans, rodents, and fleas) at Lima was temporarily transferred to Trujillo City, together with the field service control, from the second half of 1947 to the beginning of 1949.

The programme for every field campaign was as follows :

(1) Establishment of a plague administration unit with laboratory and epidemiological services attached.

(2) Complete epidemiological survey of the area under study.

(3) Ascertainment of the extent of rodent, flea, and human plague infection, and the exact delimitation of the area in question ; this included statistics and indices.

(4) Use of approved methods in carrying out the projected work.

(5) Evaluation of the results obtained.

(6) Comparison of these results with those obtained by using different methods of control in the same areas.

In connexion with the last item, it can be said that previous eradication of plague in Peru and Ecuador has been successfully achieved by the use of methods other than those mentioned above only at the cost of lengthy and expensive programmes. These results apply to cities (Lima, Peru ; Guayaquil, Ecuador) and ports, but not to rural plague endemic areas.

It can also be said that insecticides without residual power, flame throwers, and rodenticides such as arsenic, strychnine, thallium, squill, barium, cyanogas, etc., have proved to be of little value when used in

connexion with national programmes of plague control, even though some local successes have been obtained occasionally by their use. It is necessary, however, to distinguish true endemic areas from those where plague tends to disappear spontaneously after periods of recurring infection. Health workers have been credited often with success in treating the latter.

There is no special mention here of the methods used in eradicating plague from endemic areas ; these are outlined in Annex 1 to the committee's report.² The methods outlined below are those which have been used in Peru. They are not intended for duplication in other countries with different ecological conditions, but will be found useful as a guide in practical field work.

1. Administration

1.1 *Local Office*

- Offices (secretary, accountancy staff, inspectors, etc.)
- Bacteriological and statistical records (maps and charts, files, etc.)
- Storerooms, animals' rooms (for new and inoculated animals)
- Repair shop
- Garage

The essential services of emergency field work in rural areas may be run in tents.

1.2 *Personnel*

1.2.1 *Senior staff*

- Director-epidemiologist
- Field officer in charge of field operations
- Medical officer with laboratory experience and training in entomology
- Head inspector for the direction of approved field work
- Statistician

1.2.2 *Subordinate field personnel*

- 1 brigade inspector for every 5 inspectors
- 1 crew of workmen for trapping rats (2 inspectors and 2 labourers for every 300-400 daily wire cages)
- 1 crew of workmen for collection of rat nests and their fleas (1 inspector and 2 labourers for every 10 daily nests)

² See page 11.

1 laboratory assistant and 6 helpers (2 for general work, 1 for animal care, 3 for "depulization" of rats and nests)

Crews of 5 inspectors each, and 1 or 2 workmen for each inspector, to take charge of the application of insecticides and rodenticides

1.2.3 *Subordinate office personnel*

Administrative officer

Typist

Clerks

Storekeeper

Drivers

2. Laboratory and Epidemiological Section

2.1 *Epidemiology*

2.1.1 Human, rodent, and flea plague statistics.

2.1.2 Census of rat-flea population, using absolute rat-flea index outlined in Appendix 1.³

2.1.3 Epidemiological maps and charts kept up-to-date in a visual way.

2.2 *Laboratory*

2.2.1 *Rat examination and inoculation*

2.2.1.1 Every rat is inoculated.

2.2.1.2 Heart blood culture in agar-sulfide media for every guinea-pig on the second or third day after inoculation.

2.2.1.3 Autopsy of rats and guinea pigs.

2.2.1.4 Microscopy.

2.2.1.5 Bacteriological work.

2.2.2 *Flea examination*

2.2.2.1 Collection from rodents and rodent nests.

2.2.2.2 Identification.

2.2.2.3 Inoculation (if possible, not more than 20 per pool); this may follow any scheme (per species, per sex of rats and fleas, per localities, etc.).

³ See page 24.

3. Field Work

3.1 *Method*

3.1.1 Cities are worked block by block, each block forming a unit of work.

3.1.2 Rural areas are divided arbitrarily, mainly on the basis of one hectare per unit. Working units and premises are delimited and numbered with the aid of aerophotographic maps.

3.1.3 The work should be systematic and performed in two to three months, once a year, in any given locality. Urban plague control under epidemic conditions calls for 15 days of work. Rural work varies according to the size of the area, the number of workmen, the type and number of premises, the agriculture, the species and distribution of rodents, etc. Work in general should be intensive and terminated early enough to avoid the replacement of the rat and flea populations.

3.1.4 The formula given in Appendix 2⁴ is used to determine either the number of personnel needed to work an area in a fixed time, or the number of days needed for the same purpose by a crew of definite size.

3.1.5 DDT has been found after various trials to be the most effective insecticide when used at 5%-10% in pyrophyllite, talc, or similar powders. It is used inside buildings, mixed with cornflour to a final concentration of 2%, for dusting purposes when the stocks of DDT are low and treatments have already been performed with a higher concentration of DDT.

3.1.6 Each application of DDT dusting powder is followed by an application of rodenticide. Sodium fluoracetate (1080) has been proved to be the best poison for rodents, if used properly. Some other poisons, like ANTU, have been discarded, but their value is not questioned.

3.1.7 The number of times that an area requires to be treated depends on the absolute index obtained after each treatment and on the presence of plague in fleas or rodents. Occasional residual plague has been found on flea-free rodents, and plague infection has been found in dead fleas which have remained in their nests. These findings might not have epidemiological significance, but they call for a detailed analysis of local conditions.

3.1.8 The final results are evaluated in terms of absolute reduction of plague vectors and plague reservoirs, absence of rodent plague proved by continuous search (rat and flea examinations), and absence of human plague. In some well-treated areas surrounded by permanent plague-infected areas, reinfection did not occur until three years after the one

⁴ See page 27.

treatment. The replacement of the flea population in its original size in some urban districts took place after 26 months, but in the whole city this occurred only after three years. In Huacho, plague re-infection followed immediately after the latter period. In rural areas where there is a high density of rats (Hacienda Laredo) and where there is a continuous interchange of rodents with non-treated adjacent areas, plague recurred after one year. The infection was unevenly distributed, and occurred in particular in those areas where the flea population had reached its original index. We found from experience that the application of insecticides and rodenticides was best repeated at yearly intervals.

3.2 *Insecticides*

3.2.1 In epidemic areas, DDT is "surface" applied at first.

3.2.2 DDT dusting powder of 10% or 5% concentration is applied using centrifuges of different types.

3.2.3 DDT applications include the bed and clothes of plague patients and all their contacts.

3.2.4 DDT is used mainly to destroy the free vectors of plague; therefore, the surfaces where vectors are not found, such as open spaces, chicken yards, gardens, etc., are not treated.

3.2.5 The average amount of DDT dusting powder (5% or 10%) required for surface application is 2.5-3.0 g. per m.².

3.2.6 In endemic-enzootic areas, surface DDT is applied only to selected places. In these areas, as well as in the epidemic ones that have been "surface" treated, DDT is "subsurface" applied. The latter expression is used to describe the treatment of rat burrows and harbourages, runs and passages, double walls, attics, open-air spaces under the floors of houses, cellars, etc.

3.2.7 DDT dusting powder is applied to burrows with the foot-pump commonly used for cyanogas dusting. The average amount of DDT dusting powder (5%-10%) required per burrow is 50 g. and per average Peruvian house, 300 g.

3.2.8 DDT was not used to destroy all species of fleas, but for the selective destruction of plague vectors. In Peru it is used to control *Xenopsylla cheopis*. To be effective, DDT has to kill at least 95% of plague vectors. The destruction should be evaluated by using the absolute rat-flea index obtained through census.

3.2.9 DDT used in oil, kerosene, or water dispersive is not recommended for plague work, and DDT dusting powder of higher concentration than 10% does not give better immediate results or more permanent residual action.

3.2.10 When more than one application of DDT is needed, the powder is stained with any kind of non-toxic earth colour, as this provides better control of the inspectors' work.

3.2.11 The destruction of fleas is desirable for purposes other than plague control, and when such is the case the method of control has to be altered. This is particularly applicable to chicken-fleas. The destruction of all species of fleas in an area is much more expensive than the mere routine control of plague vectors alone.

3.3 *Rodenticides*

3.3.1 Sodium fluoracetate (1080) is used in baits in the proportion of 5 per 1,000.

3.3.2 Baits are offered in the form of cakes, quaker-oats, or plain water. The addition of traces of vanilla increases sevenfold the attraction to the baits.

3.3.3 The baits are distributed in the proportion of 7 to 10 doses per average Peruvian house.

3.3.4 Pre-baiting is convenient for census purposes, though not included in the routine work. It has been found after experiment that the average effectiveness of the baits as distributed above is 20%.

3.3.5 Baits are placed in the soil, in burrows, in elevated places, and in streams, and are classified accordingly for statistical purposes. The selection of the localities to be baited is relative to the habits of the rats, the species involved, and the use to which the building is put.

3.3.6 Poisoning resulting in an effective destruction of rats, if carried out again, will cause the destruction of a large number of mice. This does not happen at the first application of the poison, nor at the second if the first application has not destroyed most of the rat population.

3.3.7 Field experiments have shown that rats are more attracted towards baits containing 1080 than the same baits containing ANTU, in a proportion of 4 to 1.

3.3.8 Every poisoned rat collected in the field is inoculated into guinea-pigs. Pools of not more than 10 rats' spleens and livers are used for cutaneous inoculation only to prevent secondary poisoning of guinea-pigs.

3.3.9 1080 is an effective secondary poison for fleas that suck the blood of poisoned rats, but is unreliable as an insecticide and cannot replace DDT.

3.3.10 The mixture of DDT dusting powder and 1080 powder (5 per 1,000) is effective in laboratory trials, when the rats get poisoned by licking their fur. However, field application of this mixture should be avoided because of the potential danger to workmen and other humans. DDT dusting

powder is poisonous to rats, the average lethal dose being 0.5 g. pure DDT, but the range of toxicity varies from 0.05 g. to 1.0 g. It is not reliable as a poison and cannot replace rodenticides for the field control of plague.

3.3.11 Secondary poisoning of cats when they eat poisoned dead rats is one drawback of this method of rat destruction, but this is not of great importance as only 1 cat per 1,000 rats killed is affected.

4. Records

4.1 *Epidemiology*

4.1.1 Spot maps of plague cases (humans, rats, fleas) before field work.

4.1.2 Spot maps of plague cases (humans, rats, fleas) after field work (monthly).

4.2 *Field work*

4.2.1 Spot map showing progression of DDT and 1080 work.

4.2.2 Location of personnel.

4.2.3 Variations of rat and flea populations in treated areas.

4.2.4 Daily inspection report on DDT or 1080 work.

4.2.5 Summary record of DDT and 1080 work per block, or unit of area.

4.2.6 Final statistical report per district and for the whole area.

4.3 *Laboratory*

4.3.1 Daily report on trapped rats (species, sex, inoculation, etc.)

4.3.2 Daily report on fleas (rats and nests, classification, inoculation, etc.).

4.3.3 Absolute rat-flea index, before and after the campaign.

4.3.4 Individual record for inoculated guinea-pigs.

4.3.5 Summary record of plague strains.

4.3.6 Individual record for human cases of plague.

4.4 *Administrative records*

4.4.1 Records for personnel (assistance, salaries, leave, etc.).

4.4.2 Cost of operations.

4.4.3 Material (expenditure, averages, etc.).

4.4.4 Inventories.

5. Supervision

5.1 Work is assigned weekly.

5.2 Inspectors are supervised by permanent brigade inspectors and by a head inspector. The officer in charge of field operations analyses the daily reports and makes field inspections of work not included in the ordinary established routine as, for instance, a greater application than average of DDT per burrow.

5.3 Daily reports that have been approved are recorded per block or other unit of work.

5.4 Partial or final reports are based on these units.

5.5 Summarized analytical reports are based on districts (residential, commercial, suburban or rural, waterfront, etc.).

5.6 The laboratory and epidemiological work is supervised by the director.

5.7 The final reports and statistical analyses are made by the director who then presents them to the national health-authorities and the Pan American Sanitary Bureau.

Appendix 1

Practical Absolute Rat-Flea Index Used in Plague Control⁵

1. Plague, except for the pneumonic form, is exclusively the result of the amount of potential vectors present, even under the most favourable epidemiological conditions. The results of plague control can, therefore, be better ascertained by measuring the degree of flea control attained.

2. Results have until now been appraised through the use of relative rat-flea indices, either global or specific. However, this method is of little value when plague-control work is applied to both rats and fleas. Relative flea indices cannot be applied in the case of unknown and varying rat populations. Moreover, they require monthly indices for at least a year,

⁵ The word absolute is used here in the sense of complete, the index being the true expression of the relation between the absolute rat and rat-flea populations of an area. The index is, by definition, expressive of a relative value.

and this is not possible for areas that have not been previously surveyed. The common rat-flea index does not give the actual size of the absolute rat or flea population, and does not include fleas living in rodent nests. It is subject to external weather conditions as these cause the shifting of the flea population from rats to nests or vice-versa, and there is no way, up to the present, of evaluating these variations. The relative index is also influenced by the unusually high counts of fleas collected from some rats. Because of all the reasons mentioned above, it has little value for purposes of comparison, unless observations have been made over long periods of time.

3. The elimination of most of these drawbacks can be effected by the use of the absolute rat-flea index, which represents the relation between the real rat and rat-flea populations of an area, including the nest-flea population. It gives the average number of fleas (including nest-fleas) that, theoretically, feed on one rat. Any change in the rat-flea or nest-flea population is reflected in the index, as is also any change in the number of rats or nests. The variations incurred by unfavourable climatic conditions causing the fleas to confine themselves to the rodents' harbourages (the latter phenomenon also taking place when the fleas are not feeding, etc.) do not, thus, affect the absolute index.

4. The main object of the new formula was to bring about a practical way of estimating the results of plague-control work carried out with the aid of insecticides with residual action and powerful rodenticides. The intensity and duration of the control work are determined by accurate evaluation, in the shortest time, of the remaining rat and flea populations in the treated area.

5. The absolute rat-flea index does not include free rat-fleas, though these are quite numerous in many places, nor fleas specific to other animals or man, except when these are found on rats or in their nests. There is no accurate way of counting the free flea population, as any methods used for trapping them have yielded but a small number. Free *Xenopsylla cheopis*, the principal vector of plague in South America, are scarce in the off-season for plague, but increase in number when external climatic conditions are favourable. This sudden increase in *X. cheopis* is sometimes due to the wandering of individual fleas from their hibernating or breeding places to search for hosts. As these places have no relation to rats, *X. cheopis* are never infected with plague and should be distinguished from those that wander after abandoning dead plague rats, the latter being the most dangerous plague vectors when infected. Nevertheless, in the index, the *X. cheopis* that are resting in their breeding places are included in the category of rat-nest fleas. Wandering free rat-fleas are neither considered in the new index, nor in the relative rat-flea indices in present use.

6. The formula for the absolute rat-flea index is as follows :

$$(a) \quad AFI = \frac{\frac{SRF \left(\frac{SR \times TA}{SAr} + 10\% \right)}{SRE} + \frac{SNF \left(\frac{SN \times TA}{SAn} + 10\% \right)}{SNE}}{\frac{SR \times TA}{SAr} + 10\%}$$

where

AFI = Absolute rat-flea index
 TA = Total area, expressed in blocks for cities, or in hectares for rural zones
 SA_r = Surveyed units of area (for rat population)
 SA_n = Surveyed units of area (for nest appraisement)
 SR = Number of rats obtained in surveyed area
 SN = Number of nests counted in surveyed area
 SRF = Number of fleas obtained from rats collected in surveyed area
 SNF = Number of fleas collected from nests in surveyed area
 SRE = Number of rats actually examined for fleas in surveyed area
 SNE = Number of nests actually examined for fleas in surveyed area
 10% = Percentage allowance, under varying conditions

AFI is equal to the sum of the total number of rat-fleas and fleas from nests, burrows, rat harbourages or breeding places, etc., divided by the total number of rats in the area, or

$$(b) \quad AFI = \frac{RF + NF}{TR}$$

in which :

$$TR = \frac{SR \times TA}{SAr} + 10\%$$

$$RF = \frac{SRF \left(\frac{SR \times TA}{SAr} + 10\% \right)}{SRE} = \frac{SRF \times TR}{SRE} = \frac{SRF}{SRE} \times TR = RFI \times TR$$

$$NF = \frac{SNF \left(\frac{SN \times TA}{SAn} + 10\% \right)}{SNE} = \frac{SNF \times RN}{SNE} = \frac{SNF}{SNE} \times RN = NFI \times RN$$

in which :

$$RN = \frac{SN \times TA}{SAn} + 10\%$$

$$RFI = \frac{SRF}{SRE}$$

$$NFI = \frac{SNF}{SNE}$$

Then,

$$(c) \quad AFI = \frac{(RFI \times TR) - (NFI \times RN)}{TR} = RFI - \frac{NFI \times RN}{TR}$$

TR = Total rat population in the area

RN = Total number of nests in the area

RF = Total flea population living on rats

NF = Total number of fleas from flea-breeding or flea harbourages, e.g., rat nests, rat burrows, rat harbourages, and similar places — all these referred to as nests

RFI = Relative rat-flea index, i.e., average number of fleas per rat

NFI = Relative nest-flea index, i.e., average number of fleas per nest

Then, the following data are required for the absolute rat-flea index formula :

- (a) Rat population of the area
- (b) Flea population living on rats
- (c) Flea population living on nests

These data are obtained by cross-section surveys of rodent and flea populations, similar to those used in the partial census of the human population, and a cross-section counting of nests in a representative limited area.

For practical purposes, the following data are necessary :

- (a) Absolute rat population of the area
- (b) Total number of rat nests and similar places
- (c) Relative rat-flea index, obtained by the counting of fleas in a representative number of rats
- (d) Relative nest-flea index, obtained by the counting of fleas in a representative number of nests

The practical application of the formula in field work is dealt with separately.

Appendix 2

Estimation of Personnel Required

(Formula for determining the number of personnel needed for working a plague area in a definite number of days, or the number of days needed for the same purpose when a crew of workmen of fixed size is available.)

1. *Formula*

$$K = \frac{\frac{UH}{x} + \frac{RH}{y} + \frac{HL}{u} + \frac{KM}{z}}{T} + 10\%$$

where

- K = Number of inspectors
 T = Time in days
 UH = Number of urban houses
 x = Average number of urban houses that an inspector can work in a day
 RH = Number of rural houses
 y = Average number of rural houses that an inspector can work in a day
 HL = Number of hectares of cultivated land
 u = Number of hectares of cultivated land that an inspector can work in a day
 KM = Total km.² in the area
 z = Number of km.² that an inspector can work in a day
 10% = Sunday and holiday allowance

The areas and the number of premises are obtained by aerophotographic maps (combined with real-property municipal census). This formula applies to urban and rural areas. If applied to either of these the value for the other one is nil.

x, y, u, and z are variables and should be determined by preliminary local trials in the field.

This formula could be applied to DDT or poisoning work. Both of these require the same time to be performed by the same number of workmen, unless pre-baiting is used.

2. *Application of formula*

Example : Trujillo valley

Inhabitants, Trujillo City	60,000
Blocks	180
Houses	7,292
Houses in other cities and villages . .	2,783
Rural houses	1,018
Cultivated area	500 ha.
Total area	100 km. ²

The cultivated area is exclusive of sugar-cane plantations, which are not involved in plague.

Data obtained after trials :

$$x = 40$$

$$y = 20$$

$$u = 1.2$$

$$z = 0.3$$

If 90 days are available for the performance of the work, the number of inspectors required can be calculated as follows :

$$K = \frac{\frac{10,075}{40} + \frac{1,018}{20} + \frac{500}{1.2} + \frac{100}{0.3}}{90} + 10\%$$

$$\begin{aligned} K &= \frac{251.9 + 50.9 + 416.7 + 333.3}{90} + 10\% = \frac{1052.8}{90} + 10\% = \\ &= 11.7 + 1.2 = 12.9 \text{ (approximately 13 inspectors)} \end{aligned}$$

13 inspectors need at least 13 labourers, 2-3 brigade inspectors, and 1 head inspector.

If a permanent crew of 15 inspectors is available for the performance of the same work, the number of days required can be calculated as follows :

$$15 = \frac{\frac{10,075}{40} + \frac{1,018}{20} + \frac{500}{1.2} + \frac{100}{0.3}}{T} + 10\%$$

$$T = \frac{1,052.8}{15} + 10\% = 70.2 + 7.0 = 77.2 \text{ (approximately 77 days)}$$

Appendix 3

Outline of Plague Control — Local Government Field Teams

The committee considered that the field control organization developed in South America by Dr Macchiavello could be taken as a guide for organizing work in the field suitably adapted for local conditions. It recom-

mended that the list of personnel shown in Dr Macchiavello's note be modified as follows :

Administration

1. *Personnel*

On the basis of experience in South America, the following staff is the minimum requirement of a field control team :

Senior staff :

epidemiologist
field officer in charge of field operations
entomologist

In selecting this personnel, at least one of the members must be a medical officer and an effort should be made to ensure that the personnel should possess between them knowledge of bacteriology and laboratory techniques.

Subordinate staff :

one head inspector per every five inspectors
one crew of workmen for trapping rats
one crew of workmen for collection of fleas from rats' nests

One inspector could take charge of both DDT and poison work. It is presumed that the local facilities of hospitals, public-health services, and base laboratories will be available to the team.

2. *Secretarial and records*

3. *Supplies*

4. *Service*

Annex 4**CLASSIFICATION OF HUMAN CASES OF PLAGUE, BASED ON CLINICAL, EPIDEMIOLOGICAL, AND LABORATORY DATA¹**

In countries where plague occurs in extensive areas and suspected cases are dealt with by a number of physicians, a definite and objective criterion must be established for the diagnosis of human plague in order to secure uniform grounds for judgement and to guarantee sound comparability of morbidity and mortality data.

According to such considerations, the National Plague Service (Serviço Nacional de Peste) of Brazil has developed a classification key based on concrete clinical, epidemiological, and laboratory data, as follows :

1. Clinical Diagnosis**1.1 Positive (P)**

Actual evidence of clinical symptoms typical enough to lead the physician to establish with a good margin of safety the diagnosis of plague.

1.2 Suspect (S)

Reference to clinical symptoms of plague made by recovered or convalescent patient, or collected from the contacts of a case that has been moved from the place or died before the investigation.

1.3 Negative (N)

Absence of clinical symptoms of plague or absence of direct or indirect history of such symptoms.

1.4 Not defined (X)

Absence of any basis for classification.

2. Epidemiological Diagnosis**2.1 Positive (P)**

Evidence of association with confirmed cases of human or rodent plague. (Previous or simultaneous positive human cases or plague epizootics confirmed by laboratory, in the neighbourhood.)

¹ Submitted by Dr A. Castro, Director, National Plague Service, Ministry of Education and Health, Rio de Janeiro, Brazil.

2.2 *Suspect* (S)

Existence of these same facts, not confirmed, however, by laboratory or not subjected to laboratory tests.

2.3 *Negative* (N)

No evidence of any association whatsoever with occurrence of human or rodent plague.

3. Laboratory Diagnosis

3.1 *Positive* (P)

Bacteriological isolation of *Pasteurella pestis* from the suspected material.

3.2 *Negative* (N)

Negative laboratory tests for *P. pestis*.

3.3 *Not defined* (X)

Cases from which it was not possible to obtain samples for laboratory examination in due time, and cases from which the collected samples were lost or became unsuitable for examination.

4. Final Classification Key

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Clinical diagnosis	P	P	P	P	P	P	P	P	P	S	S	S	S	S	S	S	S	S
Epidemiological diagnosis	P	P	P	S	S	S	N	N	N	P	P	P	S	S	S	N	N	N
Laboratory diagnosis	P	N	X	P	N	X	P	N	X	P	N	X	P	N	X	P	N	X
Final classification	P	P	P	P	P	P	P	S	S	P	S	S	P	S	S	P	S	S
	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
Clinical diagnosis	N	N	N	N	N	N	N	N	N	X	X	X	X	X	X	X	X	X
Epidemiological diagnosis	P	P	P	S	S	S	N	N	N	P	P	P	S	S	S	N	N	N
Laboratory diagnosis	P	N	X	P	N	X	P	N	X	P	N	X	P	N	X	P	N	X
Final classification	P	S	S	P	N	N	P	N	N	P	S	S	P	S	S	P	N	N
Positive — combinations :	1, 2, 3, 4, 5, 6, 7, 10, 13, 16, 19, 22, 25, 28, 31, 34																	
Suspect — combinations :	8, 9, 11, 12, 14, 15, 17, 18, 20, 21, 29, 30, 32, 33																	
Negative — combinations :	23, 24, 26, 27, 35, 36																	