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Biological warfare. Current concepts of potential and defense, with emphasis on civil defense.

by Dr. J. Albrecht, Trier.

A West German survey of the implications of biological warfare, stressing its defensive aspects, translated by the Technical Library, Technical Information Division.

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A) Definitions.

"Biological warfare" involves the employment of living organisms or their toxic products or a number of special, synthetic substances with the aim of inducing disease with or without fatal termination in human beings, animals or plants.

A "disease" is any disturbance of normal vital functions and of the individual's well-being.

The offensive agents used in biological warfare (BW) are herein called "biological agents."

B) Employment.

1. Agents. Table 1 lists potential BW agents. Selection criteria:

a) Suitability for rapid and economical manufacture in adequate quantities.

b) The material must be in a form conducive to transport and effective delivery.

c) It must attack the individual in a concentration sufficiently strong to be effective.

d) The agent must be highly infectious and pathogenic. An automatic dissemination of the disease is desirable.

e) Defenses should be weak or non-existent.

f) The attacker must retain control of the effect in order to prevent its dissemination to friendly areas.

Requirements placed on a biological agent in a) - f) may be amplified as follows:

Ad a) Industrial methods can produce large amounts of different microorganisms and toxins in a relatively short time. Production of viruses requires special installations for their cultivation on living tissue.

Nowadays, only a few types of virus and bacteria resist growth on tissue cultures or other nutrient media (e.g. hepatitis virus, trachoma virus, leprosy bacteria).

The cultivation of pathogenic protozoa is also difficult.

Ad b) Freeze drying (lyophilization) produces large amounts of compressed and preserved microorganisms, which are easily transported. Viability is extended or limitless.

Ad c) Aerosols contaminate extensive stretches of air, water and material with germs and toxins.

Pathogens not entering the respiratory or alimentary tract are practically worthless (e.g. gas gangrene, tetanus) unless carried by vectors. Certain organisms are sensitive to light, dryness, etc., making their delivery by air unlikely (e.g. meningococci, pneumococci).

Table 1: Diseases and pathogens suitable for employment as BW agents.

	Man	Animal	Plant
Viruses (including rickettsia)	Yellow fever Ornithosis (parrot disease, etc.) Viral encephalitides Lymphocytic choriomeningitis Dengue fever Grippe (influenza) Small pox Diseases due to enteroviruses (ECHO, Coxsackie, etc.) Rickettsiosis (spotted fever, 5-day, Q, Rocky Mountain, etc.)	Rinderpest Foot-and-mouth disease Fowl plague Atypical fowl plague (Newcastle disease) Hog cholera Bovine pleuropneumonia Epizootic encephalomyelitis (in hogs: Teschen disease) Rift Valley fever	Potato crinkle
Bacteria	Anthrax Glanders Melioidosis Plague Tularemia Relapsing fever Brucellosis (Bang & Malta fever) Infectious intestinal diseases (typhus, paratyphus, enteritis, dysentery, cholera) Tuberculosis Diseases due to staphylococci Diseases due to botulin toxin	Anthrax Glanders Brucellosis Pasteurellosis (cattle and swine plague, ovine septicemia, fowl cholera) Infectious intestinal disorders	Potato ring rot Mildew of apples, pears and beans

	Man	Plant
Fungi	Histoplasmosis Blastomycosis Coccidioidomycosis	Black cereal rust Corn rot Potato leaf rot
Miscellaneous	Arthropods as vectors of infective pathogens, e.g. Mosquitos (yellow fever, dengue, Pappataci fever, Rift Valley fever, Oroya fever, tularemia) Ticks (Taiga encephalitis, fowl plague, tick fever, tick relapsing fever, tularemia) Lice (typhus fever, Volhynia fever, Q fever, relapsing fever) Gadflies (tularemia) Mites (mite spotted fever, fowl cholera) Flies (pathogenic intestinal germs, anthrax)	Animal parasites, such as wire worms, potato beetles, June bugs, aphids Weed seeds Synthetic substances: "Weed"-killer, growth substances

Ad d) Preference is given to highly pathogenic and contagious agents. Some pathogens have a weak infectivity (e.g. actinomycetes) and/or pathogenicity (e.g. poliovirus).

Ad e) Specific protection is offered by natural or artificial immunization (e.g. measles, chicken pox. poliomyelitis) or by prophylactic or therapeutic dispensation of antibiotics. The attacker prefers agents for which no specific counter-measures exist, e.g. viruses.

Ad f) If a spreading of disease from enemy to friendly lines is likely, the agent in question probably will not be used. Unless his troops have been protected, the enemy will not contaminate an area he intends to occupy.

The list of biological agents in Table 1 makes no claim to completeness. It may be expanded when it becomes possible

a) to employ pathogens excluded by the preceding criteria and

b) to select pathogens with undiscovered properties or to produce these artificially.

Ad a) The following possibilities are suggested:

I. Development of new methods of cultivation for pathogens currently eluding culture,

II. Utilization of unusual routes of dissemination not existing in nature and unknown to date,

III. Selection of particularly virulent strains of germs (e.g. with increased toxin production),

IV. Selection of bacteria resistant to certain remedies,

V. Selection of bacterial strains that differ from the customary types (e.g. in their cultural morphology), rendering their identification difficult, if not impossible,

VI. Development of new protective methods (e.g. immunization) for the attacker's safety.

Ad b) It has been established that new diseases may appear from time to time, caused by pathogens limited in their similarity to existing organisms. The genesis of unknown types usually is based on spontaneous mutations.

Such "spontaneous" mutations may be promoted by experimental treatment requiring complicated processes. A simpler method is offered by recombination of genetic material. It makes possible an aimed search for "new" pathogens. Mechanisms such as transformation, conjugation, transduction, conversion effect the transmission of the carrier of specific properties (in the form of desoxyribonucleic acids) from one bacterial or viral type to another. In this manner, avirulent pneumococci may be rendered virulent by addition of the genetic substance of virulent pneumococci. Other changes include the transfer of "resistance to streptomycin." Artificial transmission may create new types of organisms, possibly even new species. Introduction of foreign amino acids may result in new combinations among the simpler viruses.

There are indications that the range of mutation is limited by the law of constancy, enforced by the development of lethal combinations between different species. The question of unknown pathogens in BW may be answered as follows:

I. Among bacteria, we can expect types that belong to known species, but possess new properties.

II. It is uncertain whether completely new viral types can be expected. Physicians and epidemiologists may see "apparently new" diseases rather than "really new" ones in BW, but this possibility cannot be entirely discounted.

2. Routes. Delivery and dissemination of biological agents may proceed along two principal routes, i.e.

a) on a large scale directly from the air,

b) on a smaller scale by sabotage.

Ad a) BW agents are delivered from the air in aerosol form or by drop of infected items or living organisms or containers filled with infectious material.

Aerosol delivery is probably most effective. Cultures, lyophilizates or plant killers are sprayed, atomized or vaporized from aircraft, rockets or other missiles, balloons or by ground aerosol generators. Protective colloids guard the agent against injurious influences. Clouds of vapor or dust sink to earth; their dimensions and rate of descent are predictable. The agent reaches the human or animal organism through inhalation. Sediments contaminate the soil, water, food and other items. The pathogens may be disseminated further by agitation of dust.

Aerosols are best delivered in humid weather, at night and from low altitudes, since living pathogens are vulnerable to drying and sunlight. Drops from low altitudes retain necessary concentrations.

The delivery of biological agents in aerosol form is menacing for the following reasons:

I. Aerosols would include the pathogens of diseases normally transmitted by the aerial route (in man, influenza, parrot disease, tuberculosis, pulmonary mycoses, etc.) The high concentration shortens incubation and compounds the severity of illness.

II. Certain pathogens (e.g. pneumonic plague, pneumonic anthrax) induce particularly serious conditions when inhaled. These diseases are normally transmitted to man by other routes (e.g. plague by flea bites, anthrax by contact or food consumption).

III. Pathogens and toxins which normally never enter through the respiratory system may also be delivered in aerosol form. This frequently causes completely novel and nearly always very severe symptomatologies known only from laboratory experiments. These include yellow fever, viral encephalitides, spotted fever and other rickettsioses, tularemia, glanders and botulin toxicosis. Natural transmission occurs through arthropods (spotted fever, yellow fever, encephalitides), rodents (tularemia), contact (glanders) or oral ingestion (botulin toxin). Inhalation of these agents invariably leads to unusual and stubborn processes.

IV. The purification of water is simpler than that of air, especially since the human senses cannot perceive BW agents and technical detection is complicated and time-consuming.

Terrain, open water, supplies, cattle watering basins, food and fodder stocks may be contaminated by means of air-dropped containers or missiles that burst upon impact and spread toxins, pathogens or infected insects.

Table 1 lists some arthropods that may be bred, infected and delivered to the target. Many arthropods can survive unaccustomed air pressures and temperatures for some time. Finally, uninfected arthropods may be dropped on epidemic areas to help spread the disease (e.g. fleas in the case of plague). First consideration would be given arthropods resistant to known insecticides.

It is conceivable that poisoned or infected items could be dropped (e.g. money bills, purses, coins, cosmetics, drugs).

Simultaneous employment of biological agents with conventional, atomic or chemical attacks would increase reciprocal effects and impede every defensive effort.

Ad b) Biological agents could be used by saboteurs, spies, guerrillas, commando troops and similar groups. Their principal targets would be: Food and feed plants, drinking water installations, dairies, slaughter houses, food and feed depots, mess halls, ration distribution points. Pathogens may be uniformly distributed through the air conditioning systems of factories, warehouses, mines, shelters or important military installations (e.g. headquarters).

3. Effects:

a) The plant kingdom. Damage of crops by pathogens is considered less decisive, since many factors (e.g. climate, weather, soil conditions, etc.) inhibit the spread of a plant disease. Destruction of plants by chemical agents is more effective. A small number of aircraft could destroy the plant life of a whole nation for several years by employing socalled growth substances. Such a catastrophy could easily decide a war, since no preventive or defensive measures are known.

b) The animal kingdom. Artificial dissemination of epizootics among domestic animals would have dire consequences for a country's economy. Large herds would be prime targets. The protection of animals is more difficult than that of man.

c) Man. BW agents are means of mass destruction not employed against individuals. Principal targets would be the civilian population of cities, followed by certain sensitive groups, such as industrial complexes, military camps and assemblies, headquarters. The threat to front-line troops depends on the enemy's evaluation and his ability to protect his own personnel, e.g. through immunization.

Following an incubation period, a biological agent induces disabilities in the attacked organism ranging from a brief, socalled commonplace infection via chronic infirmity followed by ultimate recovery to death setting in after a short or prolonged illness. BW agents are incapable of causing instantaneous loss of life.

Not every invading pathogen causes clinical symptoms. Its effectiveness depends on the parasite-host relationship and such accompanying factors as mode of infection, weather, defensive measures. Some of the agent's properties are: Type. number, pathogenicity, infectivity, virulence. Increasing infective dosages can be expected to induce a progressively rising incidence and severity of illness.

The host protects himself against pathogens by unspecific defense mechanisms depending on constitution, nutrition, psychic equilibrium, etc. Wartime resistance is weakened by overexertion, malnutrition and emotional stress. Specific defense substances are formed after an illness, by natural immunization or by vaccination. Specific defensive substances generally protect against the corresponding pathogen. Active immunization is the best measure for the prevention of epidemics.

Biological warfare is characterized by certain peculiarities of effect, especially with respect to man:

I. An infectious disease spreads by itself. Only biological agents have this property.

II. In some cases the attacker prefers to disable his enemy, rather than kill him. BW agents have this capability.

III. Even relatively mild symptoms lower combat efficiency and morale.

IV. A single case of a serious infectious disease sets the whole epidemiological defense mechanism in motion. This burdens the defender with considerable handicaps.

V. Eons of struggle for his existence have imbued man with a subconscious dread of epidemics. This fear seems stronger in this case than in the face of other destructive weapons. A sudden and unexpected appearance of even a few cases of dangerous diseases could elicit unexpected psychological reactions among the attacked population. It is conceivable that biological agents could be employed primarily with the aim of such a reaction.

C) Defense.

The variety of BW agents necessitates defensive measures that are numerous, diverse and expensive; these require a considerable commitment of means, material and effort.

A perfect protection against BW agents does not exist.

Defensive measures against BW should be effected in three phases:

1. Intensive and thorough preparations must be carried out in times of possible conflict. Since wars are invariably accompanied by an increase in contagious diseases, these measures will prove valuable in any event.

2. When an attack has been confirmed or is being suspected, direct defensive action endeavors to protect exposed personnel against disease.

3. When the symptoms of a BW attack appear on persons, animals or plants, measures are ordered for the aid of the ill and for the prevention of epidemics.

Close coordination of all measures is imperative. Cooperation between the Federal Republic of Germany and the United States is recommended, since the latter have made great advances in this field. In Germany, an Executive Commission should be charged with the planning and supervision of all protective and defensive actions (socalled Central Defense Authority, see Table 2). Modern means of mass destruction are variform and indiscriminate; only a coordinated effort has a chance of succeeding. In the USA, the coordination of defensive agencies has been accomplished with good results (Departments of Defense, Army and Agriculture, Federal Civial Defense Agency, Public Health, Food and Drug Administration) (Fothergill).

The ensuing chapters will treat only those measures that are designed to protect human beings.

1. Preparatory measures. The moment of surprise always has disastrous consequences for the attacked. The effects of a catastrophy are greater by far when the defender is unprepared. Moreover, an aggressor will use a weapon for which no protection exists.

In detail, the following preparatory steps are recommended:

a) The study and scientific research of potential BW agents, as well as methods for their detection and control. Laboratories engaged by the Central Defense Authority must verify results obtained elsewhere and initiate own investigations into certain problems, if necessary.

b) Legal provisions and establishments for purposeful prophylaxis and control of epidemics are already in existence. Some of these require revision and augmentation to fit the control of artificially disseminated diseases. Reportability should be extended to all diseases induced by pathogens of BW potential (see Table 1).

c) The Public Health Department is responsible for the prevention and control of natural infectious diseases. Its facilities will be required to take initial defensive steps and to initiate and supervise subsequent coordinated measures on order of the Central Defense Authority. The Public Health Service should be centralized and reinforced. Its personnel should receive special training.

d) A formidable organisational problem is posed by the coordination under one defensive plan of the installations of the Public Health Service (health offices, chemical, veterinary and medical laboratories), individual workers (all physicians, including Army medical officers, veterinarians, druggists, nurses, health inspectors, medical-technical personnel, disinfectors, fumigators, etc.) and private organisations of the health establishment (hospitals, medical institutes, sanatoria, drug and vaccine factories, disinfecting installations, etc.) and related fields (chemical, zoological, biological institutes, etc.) (See Table 2). All of these must be informed and prepared.

The following example will illustrate the point: In the event of BW, diseases may appear that normally do not occur in this country (e.g. histoplasmosis) or do not take that particular form (for instance, "pulmonary" typhus fever). All physicians should be trained to recognise such diseases in writing or by lectures.

e) Present facilities and their equipment are inadequate and must be reinforced (hospitals, quarantine wards, ambulances and hearses, disinfecting stations, laboratories, etc.)

f) The production and storage of drugs, vaccines, diagnostic reagents, detergents, disinfectants, insecticides, etc. must be guaranteed.

g) Qualified and experienced specialists (physicians, microbiologists) and helpers (public health personnel) must be acquainted with the demands of BW, both among the civilian population and the military. These persons, trained at a special school run by the Central Defense Authority, man the warning, detection, reporting and control service incorporated in the general defense plan (see Table 2).

h) Adequate protection must be afforded against sabotage with biological agents.

i. The individual contributes by controlling the spread of diseases and their vectors, and must be informed by pamphlets, moving pictures, television, radio, etc. Easily understood publications are disseminated in the U.S. ("Civil defense against biological warfare;" "Emergency sanitary action in the home").

Every inhabitant should be acquainted with the following important requirements:

I. The first principle of health protection is personal cleanliness and hygiene.

II. Cleanliness must be maintained in the home and on the street even under difficult conditions (e.g. in case of war).

III. Every manifestation suggesting disease on the own body or that of another person must be reported at once to a physician, the police or other authorities.

IV. In emergencies, the individual must submit to limitation of his freedom (quarantine) or his privacy (blood tests, immunisation).

j) Active immunization usually imparts prolonged protection. Passive transmission of antibodies (socalled therapeutic sera) offers short-lived immunity. Active immunisation should be recommended to the population. This may be accomplished against yellow fever, smallpox, influenza, adenovirus infections, rickettsioses (spotted fever, etc.), typhus, cholera and tuberculosis. Vaccines against the following diseases are non-existent or under development: Dengue, psittacosis, viral encephalitides, ECHO virus infections, relapsing fever, lymphocytic choriomeningitis, anthrax, glanders, brucellosis, tularemia, dysentery, paratyphus, staphylococcal infections and fungus diseases.

k) Antibiotic or chemotherapeutic prophylaxis has certain disadvantages, such as hypersensitive reactions and development of bacterial resistance. When BW agents have been hound to be susceptible to certain remedies, their dispensation to healthy segments of the population seems indicated.

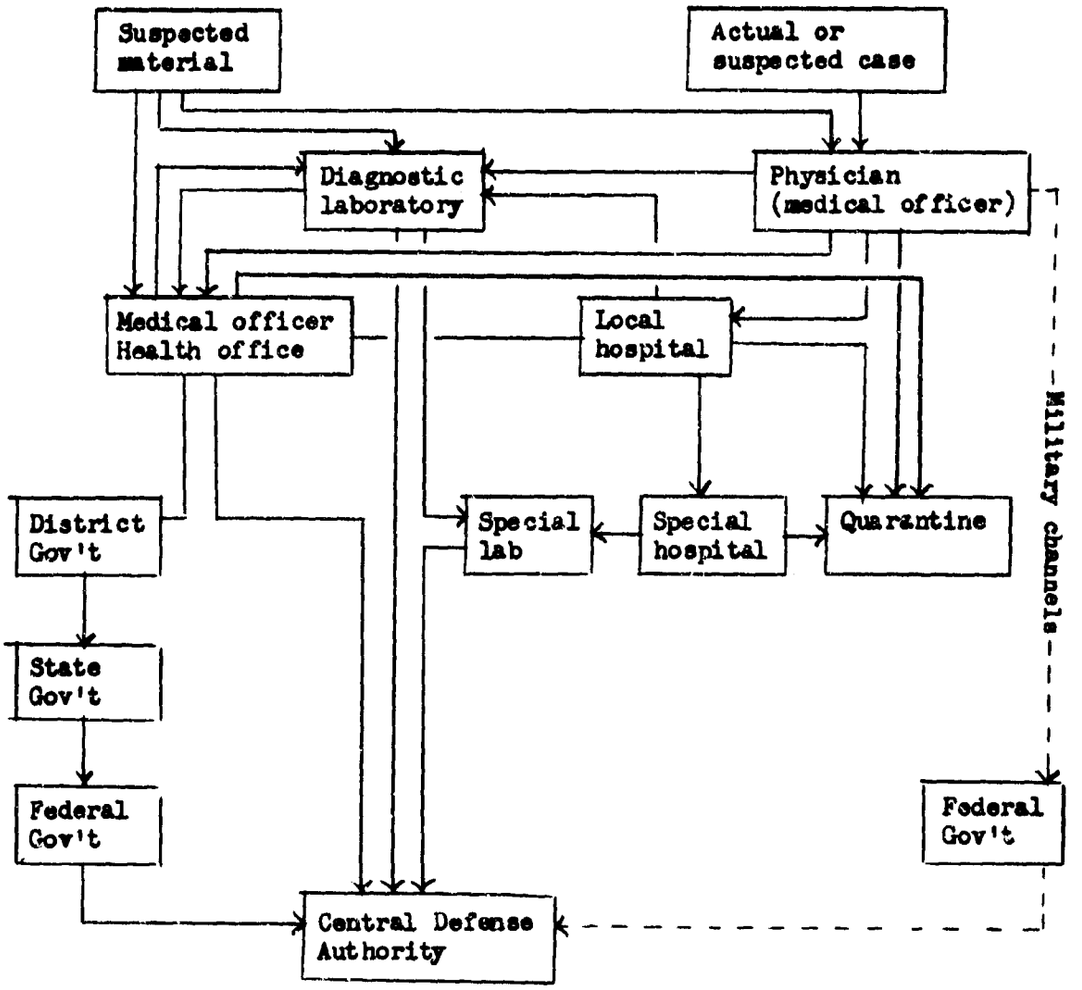
l) Rapid detection of BW agents would afford early warning and immediate implementation of defensive measures. Since these agents cannot be identified on the spot, their presence probably is first betrayed by initial disease symptoms.

Current biological methods require at least 12 hours, usually 2-3 days or even 1-3 weeks for the demonstration of living pathogens. The detection of viruses is particularly difficult due to their refusal to grow on customary bacterial media.

The improvement of detection is an urgent problem of epidemiological control. The construction of special laboratories for this purpose and the training of detection personnel are imperative requirements.

The complicated procedures employed in the identification of pathogens preclude their use on the spot by inadequately trained persons. Specimens taken by competent workers (physicians, health inspectors, epidemiological teams) from the air, water, soil, the sick and the dead should be dispatched at once to the nearest test center. Generally, these will be hygienic institutes and medical or veterinary laboratories, which could forward the specimens to special institutes in certain cases (see Table 2). Mobile laboratories could move to threatened areas in order to facilitate and accelerate identification.

Table 2: Flow chart for defense against epidemics.



2. Measures during attack. The capture of saboteurs or uncommon behavior of aircraft or missiles spraying or dropping containers may give a clue to an impending or accomplished BW attack. Protection is offered by a number of measures also recommended during other types of attack.

a) A shelter or protected spot should be sought in every case.

b) A protective mask, suit or cape must be worn.

c) Shelters, masks, etc. should be gas-proof. This also keeps out microorganisms.

d) As an expedient, exposed body surfaces, especially the mouth, nose and eyes, should be covered with towels, etc.

e) In case of suspected exposure to pathogens or bacterial toxins, the following is recommended:

The body surfaces (especially the face and hands) are to washed vigorously with water and soap. A shower is of great value. Skin disinfectants may be used alone, if washing is impossible. Infected clothes, shoes and other items are treated by washing with water, preferably by wiping with a disinfectant and airing in the sun. Laundry should be boiled.

f) Rooms and dwellings are decontaminated with formalin vapors and by scrubbing.

g) Pathogens usually die in the open and in large natural bodies of water. Special procedures (e.g. application of vaporized disinfectants, spraying of surfaces) are required only in special cases.

h) Pathogens may also enter by the alimentary route. Food and water offer substrates for the maintenance or reproduction of microorganisms and must be subjected to special treatment when suspected of contamination.

i) Although food in cans or tightly closed containers (bottles) cannot be contaminated, its natural or artificial infection prior to canning is possible. These containers should be washed or disinfected before opening. Exposed food is to be destroyed. If its consumption is necessary, it must be fried or boiled. Bread may be heated to 100°C in the baking oven. Fruit and salads are placed in 1% chloramine or permanganate solution and are subsequently rinsed with sterilized water. Fruits and vegetables may also be held at 65°C for 30 minutes or dipped repeatedly into boiling water.

j) Drinking water and potable fluids are best boiled. Boiling destroys all germs and microbial toxins except spore-formers (e.g. anthrax). Inorganic poisons and radioactive substances are not deactivated by heat. Decontaminating filters remove bacteria from the water, but frequenty pass viruses and toxins. Adequate chlorination destroys most pathogens, but not toxins and radioactive substances.

k) Every household should maintain an emergency stock of food and water, packed and stored so as to preclude contamination with any war agent.

l) Living insects appearing in conspicuous numbers or unusual insects should be attacked at one with insecticides. Home medical cabinets should contain detergents, disinfectants and insecticides in addition to dressings and medicines.

m) Tanks, containers, packages, food and condiments, insects or small animals of possible enemy origin should not be touched, but are covered with sand or dirt. Their type, location and number are to be reported at once to the authorities (e.g. civil defense, police).

3. Measures after attack. Countermeasures after an accomplished BW attack aim at the treatment of the sick and the protection of the healthy. Such steps are outlined in health regulations for specific diseases (the ordinance of 1 Dec 38 concerning control of communicable diseases); but they can be used also in connection with other infectious disorders (paragraph 12 of the regulation for the control of parrot disease). Every citizen is obligated to cooperate with the health authorities and the police. Present regulations should be extended to cover new scientific advances in the medical and epidemiological domains and should include information on the defense against artificially disseminated pathogens.

Detailed instructions are contained in pertinent legal texts.

The obligation to report actual or suspected cases of communicable diseases extends to every person. Disorders listed in the legal codes do not agree with those of Table 1, requiring the designation of the latter as reportable diseases. A prerequisite of such reporting is the knowledge of potential BW agents among physicians, medical aid personnel, civil defense and police personnel, teachers, etc., and among all citizens consistent with their status and education. The role of the physician is particularly important, since he is approached first by the population and must differentiate between commonplace symptoms and initial signs of a dangerous contagion.

The forwarding of reports and specimens, and the treatment of casualties proceeds according to the plan shown in Table 2, based on long experience in the control of natural pestilences. Rapid notification of the Central Defense Authority of all results obtained in the field is imperative for effective control.

D) Can we expect the use of biological agents?

Histories of compaigns from Alexander's time to Korea contain descriptions of attempts to employ biological agents. If these reports can be believed, the conduct of biological warfare to this day seems to have been on a small scale and somewhat amateurish, with insignificant results. At any rate, data on this subject are contradictory and difficult to verify.

Judgements and conclusions regarding the feasibility of BW and its sequels are theoretical and speculative. Moreover, BW involves scientific, political, legal and ethical factors in addition to military considerations. It is quite impossible, for these reasons, to predict whether BW operations would be employed in a future war.

The pertinent literature indicates that all experts agree on the possibility and feasibility of artificial dissemination of pathogens. There are divided opinions on its value to the attacker, i.e. the form and extent of damage suffered by the defender. Based on the theoretical possibility of BW, a number of countries have approached this problem, particularly in its defensive aspects. Thus, according to "TIME" magazine published on 23 Nov 59, a Chicago firm was awarded a $1.2 million order "to aid Army bacteriological warfare experts in the search for the best defensive measures against biological attack." Since World War II, the American armed forces have maintained a laboratory at Camp Detrick, Maryland (USA), employing outstanding scientists in research dealing with biological warfare. Since only a part of their results (probably the smallest part) has been published, a direct contact with the appropriate American authorities seems urgently indicated, preferably on the premises, in order to advance our own knowledge, which is based solely on epidemiological experience and on relatively scant and insignificant publications.

Although there are agreements on the ban of chemical and biological agents, they do not seem to afford adequate guarantees. As long as extensive and controlled international agreements do not exclude the warlike employment of biological agents, numerous countries are endeavoring to find defenses against BW. Apparently they are motivated by the conclusion that the danger of BW attack is heightened when defensive measures are ignored or neglected, and that the effects of such an attack would be inconceivably grave.

E) Literature. The author lists 33 sources, 21 of these being American, 2 Canadian, 1 Chinese, 4 German, 1 British and 4 Italian.