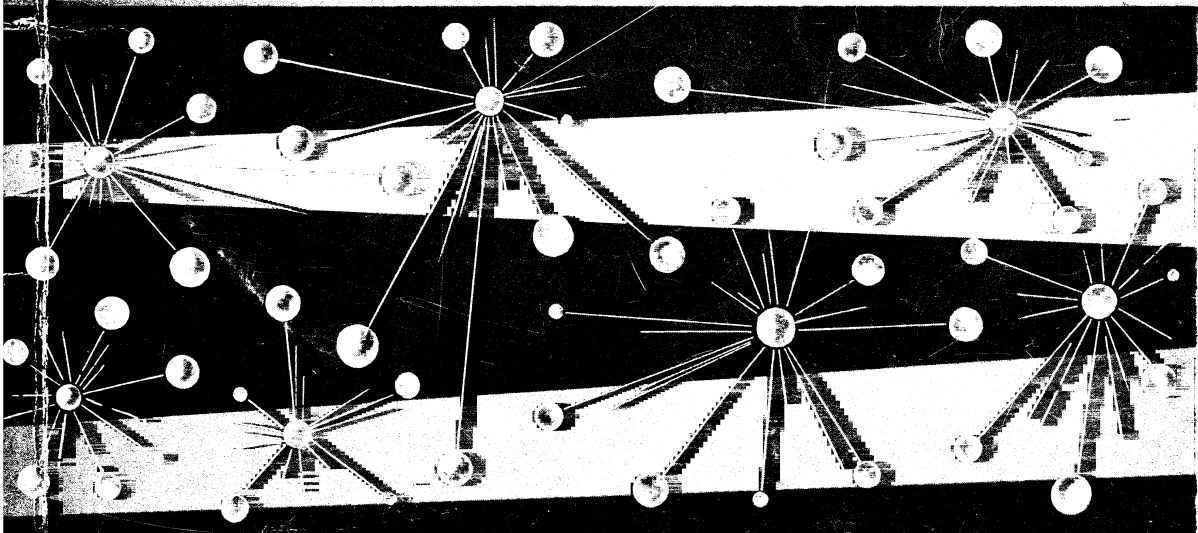


**health aspects
of chemical
and biological
weapons**



WORLD HEALTH ORGANIZATION

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1. INTRODUCTION

On 29 January 1969, the Secretary-General of the United Nations requested the Director-General of the World Health Organization to co-operate with the United Nations Group of Consultant Experts on Chemical and Bacteriological (Biological) Weapons in the preparation of a report on this subject. WHO was asked to provide such information as the Organization considered useful for the United Nations report, which was to be transmitted to the Eighteen-Nation Committee on Disarmament,¹ the Security Council and the General Assembly, if possible by 1 July 1969, as requested in Resolution 2454 A (XXIII) adopted by the General Assembly on 20 December 1968 (see Annex 7).

In order to help WHO in this task, the Director-General appointed a number of consultants. In addition, liaison was maintained with the Disarmament Affairs Division of the United Nations (which serviced the Group of Consultant Experts appointed by the Secretary-General), the Food and Agricultural Organization of the United Nations (FAO), the Stockholm International Peace Research Institute (SIPRI), and the Pugwash Organization, in order to avoid unnecessary overlap in their respective contributions.

The possible development and use of chemical and bacteriological weapons and their destructive potentialities have been matters of concern to WHO for several years. In 1967, the Twentieth World Health Assembly, on a recommendation of the WHO Executive Board, adopted a resolution (see Annex 8) welcoming Resolution 2162 (XXI) of the United Nations General Assembly and calling upon all Member States of WHO to exert every effort to implement it. The Director-General was therefore glad to meet the request to assist the United Nations in this matter, and in late May 1969 an interim report was completed and forwarded to the Secretary-General. Some of the information contained in the WHO submission was incorporated into the final report of the United Nations Group of Consultant Experts on Chemical and Bacteriological (Biological) Weapons (hereafter referred to as "the United Nations report"),² which was released to the public on 2 July 1969 and transmitted to the Eighteen-Nation Committee on Disarmament for discussion during the summer of 1969 before being

¹ Renamed on 26 August 1969 the "Conference of the Committee on Disarmament".

² United Nations (1969) *Chemical and bacteriological (biological) weapons and the effects of their possible use. Report of the Secretary-General*, New York (United Nations Publication, Sales No : E.69.I.24).

considered at the Twenty-fourth session of the United Nations General Assembly later in the year.

The relatively short period of time available for the preparation of the WHO submission to the United Nations did not permit the health and related scientific aspects of chemical and biological warfare to be covered to the extent and in the depth merited by the importance of the subject. For this reason and in pursuance of resolution WHA22.58 (Annex 9) adopted by the Twenty-second World Health Assembly in July, 1969, a further study of the problem was undertaken with a view to expanding and revising certain sections of the interim report.

2. COMPARISON OF THE WHO AND UNITED NATIONS REPORTS AND THEIR CONCLUSIONS

The United Nations report presents a comprehensive review of the problem, and includes consideration of military aspects, plant and animal diseases, ecology, and economic and security aspects, along with implications to human health. The report was intentionally written in a style that would be easily understood by governments and by the lay non-specialist reader, and it does not attempt to present highly technical information or to provide a detailed analysis of public health considerations and medical effects.

The present WHO report, on the other hand, attempts to deal with the subject of chemical and biological warfare on a more technical level and to make quantitative estimates; it is addressed particularly to public health and medical authorities. Thus the WHO report and the United Nations report are complementary. Both arrive at essentially the same technical conclusions, although inevitably there are some differences with respect to the choice of emphasis and the assessment of possible effects on public health, which reflect the differing approaches and technical orientations of the groups that prepared the WHO and United Nations reports. It is hoped, therefore, that the present document will provide the Member States of WHO with the technical information that will enable them to appreciate more fully the public health implications of the possible use of chemical and biological weapons.

The following main conclusions emerge from the WHO analysis :

1. *Chemical and biological weapons pose a special threat to civilians. This is because of the often indiscriminate nature of such weapons, and because the high concentrations in which they would be used in military operations could lead to significant unintended involvement of the civilian population within the target area and for considerable distances downwind.*

2. *The large-scale or, with some agents, even limited use of chemical and biological weapons could cause illness to a degree that would overwhelm existing health resources and facilities.*
3. *Large-scale use of chemical and biological weapons could also cause lasting changes of an unpredictable nature in man's environment.*
4. *The possible effects of chemical and biological weapons are subject to a high degree of uncertainty and unpredictability, owing to the involvement of complex and extremely variable meteorological, physiological, epidemiological, ecological, and other factors.*
5. *Although advanced weapons systems would be required for the employment of chemical and biological agents on a militarily significant scale against large civilian targets, isolated and sabotage attacks not requiring highly sophisticated weapons systems could be effective against such targets in certain circumstances with some of these agents.*

These conclusions are in harmony with the conclusions of the United Nations Group of Consultant Experts on Chemical and Bacteriological (Biological) Weapons and with the hope for further action to deal with the threat posed by the existence of these weapons, as expressed by the Secretary-General, U Thant, in the foreword to the United Nations' report.

3. AIM AND SCOPE OF THE WHO REPORT

The present report attempts to analyse the health effects of the possible use of chemical and biological weapons on civilian population groups at different levels of social and economic development, and the resulting implications for WHO and its Member States. The assessment is confined to civilian populations, and no attempt is made to consider the purely military aspects of the problem, except insofar as they may relate to civilian populations as possible targets for attack. The military aspects of chemical and biological warfare are considered in the United Nations report and in a report being prepared by SIPRI. The report also makes qualitative and quantitative estimates of the health effects of selected chemical and biological agents employed under specified hypothetical conditions.

4. WORKING DEFINITIONS OF CHEMICAL AND BIOLOGICAL WEAPONS FOR THE PURPOSES OF THIS REPORT

Chemical agents of warfare include all substances employed for their toxic effects on man, animals, or plants.¹

Biological agents include those that depend for their effects on multiplication within the target organism, and are intended for use in war to cause disease or death in man, animals or plants.²

A lethal agent is one intended to cause death when man is exposed to concentrations well within the capability of delivery for military purposes.³

An incapacitating agent is one intended to cause temporary disease or to induce temporary mental or physical disability, the duration of which greatly exceeds the period of exposure.⁴

A harassing agent (or short term incapacitant) is one capable of causing a rapid disablement that lasts for little longer than the period of exposure.⁴

Casualties are deaths or disabilities.

5. SELECTION OF CHEMICAL AND BIOLOGICAL AGENTS AS MODELS FOR QUALITATIVE AND QUANTITATIVE ASSESSMENTS

There are many chemical and biological agents that are potentially suitable for use in war. A selection of some of the more likely candidates for possible use as lethal, incapacitating and harassing agents has been made

¹ This definition is intended to exclude chemicals now employed in warfare such as high explosives, smoke, and incendiary substances (e.g., napalm, magnesium, and white phosphorus) that exert their primary effects through physical force, fire, air-deprivation or reduced visibility.

² This definition therefore excludes toxins elaborated by some microbes (e.g., botulin toxin and staphylococcal enterotoxin) when they are preformed outside the target organism. In some discussions of chemical and biological weapons, such toxins are classified as biological agents because the technology of their production resembles that of biological agents rather than that of chemical agents.

³ In lower doses, such agents can cause severe and sustained disability and certain of them may act predominantly in this way when employed in combat.

⁴ No sharp line of demarcation can be drawn between lethal and incapacitating agents used in chemical and biological warfare, because incapacitating agents can be lethal or permanently disabling under certain circumstances (e.g., in the presence of malnutrition or pre-existing disease; in infants or the aged; or when there is exposure to unusually high doses, as in enclosed spaces or in close proximity to functioning chemical or biological weapons). For similar reasons, no sharp demarcation line can be drawn between harassing agents and other anti-personnel chemical agents; furthermore, harassing agents may be used in war in conjunction with high-explosive, fragmentation or other weapons to increase the lethal effectiveness of the latter—as distinct from their employment in riot control in order to reduce injuries and to save lives.

for the purposes of this report, based on published information as well as on theoretical considerations.

The chemical and biological agents described in Annexes 1 and 2 have been selected to illustrate possible varieties of usage and effects : aerosol exposure ; sabotage of communal water supply ; quick or delayed action ; essentially non-spreading and spreading types of infective disease ; vector introduction. Qualitative descriptions are given for all of them, and a number of representative types have been selected for quantitative assessments of the effects of their possible use.

6. BASES OF THE ESTIMATES OF CASUALTIES

The actions and toxicities of the chemical warfare agents considered are reasonably well known. For many, there are generally agreed estimates of lethal doses, although it should be kept in mind that often these are based on assumptions concerning the relative susceptibility of different animal species, and that susceptibility varies between individuals. The clinical symptoms, the prognosis, and the general methods of treatment and prevention, if any, can be assessed from commonly available information.

The agents chosen for discussion as possible biological weapons are those whose clinical effects are well known ; for some of them data on approximate infective doses by inhalation or ingestion are also available, either from published information about laboratory accidents or from studies in human volunteers. However, little is known about the susceptibility of man to artificial aerosols of infective agents and about the consequences of exposure to very high doses. This report is confined to a discussion of known agents with a wide range of infectivity and lethality. Other agents could conceivably be developed. In spite of these uncertainties, it has been considered useful to attempt to predict the range of immediate effects of the agents dealt with in this report.

It is considered unlikely that the general conclusions reached in this study would have been greatly modified if it had been possible to consult classified information concerning chemical and biological agents, although the assessments concerning the feasibility of their use in particular circumstances might have been made more realistic.

The estimates of casualties recorded in Tables 8 and 10, Annex 3, are based on the number of individuals within a segment of a particular population group exposed to a given chemical or biological agent. The assumptions made and the variables taken into account are stated in Annex 3. These assumptions deal with delivery, dissemination, and persistence of the agents ; meteorological conditions ; effective concentrations and doses ; human infective doses, attack and case fatality rates ; and chemotherapy.

In the detailed analysis of hypothetical attack with tularaemia, pneumonic plague, and VX, the effects of the availability and use of health facilities on the outcome are considered (Annex 4). Annex 5 describes the possible effects of sabotage of a communal water supply with botulinum toxin, the typhoid bacillus and LSD.

The estimates of casualties that are given in Annex 3 are applicable to a surprise attack on an urban area that possesses no specific protection against attack with chemical and biological agents, and in which the buildings are freely ventilated. It will be seen that even where the target area is not very densely populated the effects of attack by a single aircraft could create health problems of unprecedented magnitude.

It is certain that the scale and effectiveness of an attack (and also the cost and feasibility) would depend upon military technology. To discuss this aspect in any depth is outside the terms of reference of this report. A limited attack on a civilian population using a pattern favouring the effectiveness of the weapons employed has therefore been chosen for consideration. In this way, it is hoped to illustrate the scale of the danger that could arise from the use of such weapons. Similar results could be produced by attacks on a larger scale if the circumstances were unfavourable for the pattern chosen.

7. LONG-TERM EFFECTS

A few general considerations regarding the possible long-term effects of chemical and biological agents should be noted. First of all, insufficient knowledge is available to allow reliable predictions to be made. In many cases, not much more can be done than to outline the various possibilities needing further study. Beyond that, there are problems of evaluation that, while still having a considerable technical component, also involve value judgements that are clearly beyond the scope of this report. For example, in comparison with the direct effects of a lethal chemical or biological attack, a limited risk of long-term harmful effects to health may seem relatively unimportant. On the other hand, the long-term effects of the military use of agents that are not directly lethal may be considered more important than their immediate effects. In the latter connexion it should be kept in mind that non-military experience with disease-causing organisms and chemicals present in the environment may not be a good guide to the effects of those same agents under the quite different conditions and in the generally higher doses involved in their military employment.

Possible long-term health effects of chemical and biological warfare include (1) chronic illness caused by exposure to chemical and biological agents (see specific descriptions in Annexes 1 and 2); (2) delayed effects in persons directly exposed to chemical and biological agents; (3) creation

of new foci of infective disease ; and (4) effects mediated by ecological changes.

Delayed effects of direct human exposure

There is wide concern at present regarding the possibility that exposure to both infective and chemical agents already present in the human environment may cause harmful effects of a delayed nature. The effects of greatest concern are :

(a) *Carcinogenesis.* Both viral and chemical agents have been strongly implicated in the causation of cancer in man. Whether infection by any of the viruses contemplated for possible military employment can be carcinogenic in man is not at present known. A limited amount of information is available on the ability of certain classes of chemicals to induce cancer, mainly in experimental animals. For example, many alkylating agents have been found to be carcinogenic. Some compounds of military interest, such as mustard, CS, and others, are alkylating agents. As discussed in Annex 1, there is evidence suggesting a significant increase in respiratory tract cancer among veterans exposed to mustard gas in the First World War, and a large increase in such cancers has been reported among workers engaged in the manufacture of mustard gas in the Second World War.

(b) *Teratogenesis.* Certain chemicals and infective agents can cause severe damage to the developing human foetus. Thalidomide and the rubella virus are particularly well known teratogens. It is not known whether any agents likely to be used in chemical or biological warfare would have teratogenic effects at the doses likely to be received by pregnant women in civilian populations under direct attack with or unintentionally exposed to such agents during wartime. In this regard, it may be noted that the use of 2,4,5-trichlorophenoxyacetic acid, an anti-plant chemical that has been extensively used for both military and non-military purposes, has recently been restricted by the United States Government because experiments have shown that relatively high oral doses of this compound are teratogenic in mice and rats.

(c) *Mutagenesis.* Until recent years little attention has been given to the possibility that infectious diseases or chemicals in the environment might cause detrimental alterations in the human genome. Several chemicals are known to induce such changes in experimental organisms and in cultured human cells. Infection with certain viruses causes extensive chromosome breakage in man, but it is not known whether any heritable effect results. At least in the case of rubella it can be said that genetic damage is not massive, although the induction of a lower but nevertheless significant frequency of mutations cannot be excluded.

New foci of infective disease

As discussed in Annex 2, biological warfare would entail a risk that new foci of infective disease might be established, either in human populations or in lower animals, including vector arthropods. This possibility has been discussed in the United Nations report :

“ A bacteriological (biological) attack might lead to the creation of multiple and densely distributed foci of infection from which, if ecological conditions were favourable, natural foci might develop in regions where they had previously never existed or in areas from which they had been eliminated by effective public health measures.”

Effects mediated by ecological change

The possibility of the direct establishment of new foci of disease has been referred to immediately above. New foci might also be established as the result of ecological changes following the use of biological agents infective for man and animals. This possibility has also been discussed in the United Nations report :

“ ... the large scale use of bacteriological (biological) weapons might reduce populations of susceptible wild species below the level at which they could continue to exist. The elimination of a species or group of species from an area would create in the ecological community an empty niche which might seriously disturb its equilibrium or which might be filled by another species more dangerous to man because it carried a zoonosis infection acquired either naturally or as a result of the attack. This would result in the establishment of a new natural focus of disease.”

As for anti-personnel chemical warfare, it can at least be said that the massive dissemination of several chemical agents during the First World War has not apparently caused any major long-term ecological damage in Europe.

However, new foci of human disease may also be produced as a result of the use of anti-plant agents. Extensive damage to the flora over large areas may create conditions favouring the establishment of new vectors or reservoirs of disease infective to man. One example of the way in which damage to plant life can create new health hazards is cited in the United Nations report :

“ When a forest in a state of ecological equilibrium is destroyed by cutting, a secondary forest regenerates, which contains fewer species of plants and animals than were there originally, but larger numbers of those species which survive. If secondary forest is replaced by grassland, these changes are even more marked. If one or more of the animal species which increases in numbers is the host of an infection dangerous to man (a zoonosis) then the risk of human infection is greatly increased. This is

exemplified by the history of scrub typhus in south-east Asia, where the species of rat which maintains the infection and the vector mite are much more numerous in secondary forest, and even more so in grassland, so increasing the risk of the disease being transmitted to people as forest is cleared.”

Finally a profound long-term adverse effect on human health could result from any major reduction in the quality or quantity of the food supply. This could occur directly from the use of anti-crop agents or indirectly through ecological changes that might result from chemical or biological warfare.

8. SUMMARY

A. *Qualitative considerations*

Chemical and biological agents that might be considered for possible use in warfare are described in Annexes 1 and 2, and pertinent assumptions and other background factors are considered earlier in this text and in Annexes 3, 4, and 5. Also of importance, although more difficult to assess, are the possible long-term effects referred to in section 7, and the psychosocial consequences associated with the problem of chemical and biological weapons (see Annex 6).

The rapid action of the lethal *chemical agents* (see Annex 1) would preclude any large reduction of mortality by specific treatment. Possible protection by gas masks or shelters requires a highly disciplined and prepared population, a condition that is not fulfilled in most countries today, and it would pose serious economic and psychosocial problems if such a defence programme were to be implemented.

The outstanding characteristics of *biological weapons* (see Annex 2) for potential use in warfare are the following :

(a) The large variety of biological agents and the possible combinations available for such purposes.

(b) The possibilities for manipulating currently circulating strains of micro-organisms for warfare purposes, by producing antigenically modified or antibiotic-resistant types (tularaemia, plague, anthrax, influenza) that would by-pass available prophylactic or therapeutic procedures.¹

(c) The unpredictability of the direct effects. A biological attack intended to be highly lethal might prove relatively ineffective, whereas an attack intended to be merely incapacitating might kill an unexpectedly

¹ Mass immunizations would be of doubtful protective value because of the multiplicity of agents and strains that might be employed, quite apart from the adverse immunological side-reactions to be expected.

large proportion of the target population. Also, certain agents (anthrax, coccidioidomycosis) could persist for long periods in a resistant spore form, which could be spread over very large distances by wind carriage in the course of time.

(d) The unpredictability of secondary effects such as the likelihood of contagion and the danger that epidemics might be initiated. There is the additional danger that epidemics might occur unintentionally through escape of virulent strains being purposely sought in laboratories.

(e) Although biological agents themselves are easy to produce, complex production and delivery systems are needed if even minimal reliance is to be placed on the outcome of an attack, except perhaps where the intention is simply to produce social disruption by a limited sabotage effort (e.g., the introduction of smallpox).

Of the above characteristics, (a) and (b) would favour the attacker, whereas (c) and (d) would reduce the value of biological weapons from a military point of view.

B. *Quantitative estimates* (Tables 8, 9 and 10, Annex 3)

1. Assessments have been made of the primary effects of possible small-scale airborne attacks on cities of 0.5-5 million population in industrially developed and developing countries. The postulated mode of attack consisted of one or a few bombers dispersing specific chemical or biological agents along a 2-km line perpendicular to the direction of the wind. On the basis of the particular assumptions employed, the following conclusions have been reached :

(a) Of the known chemical warfare agents, only the nerve gases, and possibly botulinum toxin, have a casualty-producing potential comparable to that of biological agents.

(b) Under atmospheric conditions favourable to the attacker, an efficiently executed attack on a city with 4 tons of sarin (requiring some 15-20 tons of weapons) could cause tens of thousands of deaths in an area of about 2 km². Even in unfavourable conditions there could be thousands of deaths. If 4 tons of VX were used in such an attack, the casualties would not be appreciably greater in unfavourable meteorological conditions, but in favourable conditions this small attack would affect an area of about 6 km² and could cause anywhere between 50 000 and 180 000 deaths.

(c) If a suitably stabilized botulinum toxin or a fine aerosol of VX (particles of 5 μ diameter) were developed and 4 tons were employed, several hundreds of thousands of deaths could result because of the greater coverage possible with such agents—12 km² for botulinum toxin and 40 km² for monodispersed VX aerosol. A larger total weight of weapons, perhaps

2-3 times that needed for the agents in (b) above, would have to be used to deliver these forms of botulinal toxin and VX.

(d) If a biological agent such as anthrax were used, an attack on a city by even a single bomber disseminating 50 kg of the dried agent in a suitable aerosol form would affect an area far in excess of 20 km², with tens to hundreds of thousands of deaths. A similar attack with any one of a number of other more labile biological agents could affect from 1 km² to more than 20 km², depending upon agent used, with tens to hundreds of thousands of casualties and many thousands of deaths.

2. Limited sabotage of a communal water supply with the typhoid fever bacillus, LSD, or a stable botulinal toxin, could cause considerable disruption and deaths in a large city (see Annex 5), affecting tens of thousands of people.

3. Sabotage-induced or open attacks, causing the secondary spread of epidemics of yellow fever, pneumonic plague, smallpox or influenza, might under certain conditions ultimately result in many millions of illnesses and deaths (see Annex 2).

4. The numbers of potential casualties and deaths recorded in this report represent the possibilities arising out of a very small and limited attack already well within the capabilities of a number of nations, with the possibility that an ever-increasing number of countries will acquire similar capabilities. With technologically advanced weapons and a larger scale of attack, achievable without too much difficulty by militarily advanced powers, the magnitude of destructiveness attendant upon the use of chemical and biological weapons would be considerably increased.

9. IMPLICATIONS FOR THE WORLD HEALTH ORGANIZATION AND ITS MEMBER STATES

According to Art. 2 (c) of WHO's Constitution, WHO shall "... furnish appropriate technical assistance and, in emergencies, necessary aid upon the request or acceptance of Governments". The use of chemical and biological weapons would unquestionably result in extensive health and medical emergencies, including mass illnesses, deaths and epidemics, that WHO might be called upon to help overcome. An attempt to assess the magnitude of public health problems with respect to a minimal attack with selected examples of agents (tularaemia, plague, VX) is contained in Annex 4. This limited assessment, supported by analyses made in other parts of this report and in the United Nations report, reveals the very large and essentially wasteful effort that would be involved in undertaking elaborate measures for defence against specific agents. Also, as pointed out in Annex 6, such measures could well add credibility to projected fears of

annihilation in other countries. The resultant reciprocal fears between nations might contribute in turn to a proliferation of chemical and biological weapons and an accelerated arms race, resulting in vastly increased danger of accidental or deliberate release of chemical and biological agents.

Certain measures could, however, be taken within the framework of existing needs and resources that would redound to the benefit of health and preventive medical activities currently underway, and would not give rise to fears of this kind. These measures include the improvement of rapid detection and diagnostic facilities for air pollution and for communicable diseases, which would obviously be of value for health and laboratory services in general; improved medical management for natural disasters, including decontamination procedures; and the wider use of safety features in buildings (ventilation filters) and for communal water supply systems (see Annex 5). While such measures might act as a partial deterrent to irresponsible groups and might significantly reduce casualties from a very small attack or from the spreading effects of an attack on a neighbouring country, they cannot be relied upon to afford major protection to a country subjected to a determined attack.

As long as chemical and biological research directed specifically to military use is continued, it will be considered necessary by some countries to continue research towards detection of and protection against such agents. This research could in itself point to agents more destructive than those now existing. In view of the power of existing agents in conditions favourable to their use and the possibility of developing new and even more dangerous weapons, it is imperative to find ways of abolishing any presumed need for this militarily orientated research as soon as possible.

It is therefore clear that in the last analysis the best interests of all Member States and mankind in general will be served by the rapid implementation of the resolutions on chemical and biological warfare adopted by the United Nations General Assembly and the World Health Assembly (Annexes 7 and 8), and by any additional steps that would help ensure outlawing the development and use in all circumstances of chemical and biological agents as weapons of war.

Finally, there is the possibility that WHO might be called upon by the United Nations to help deal with allegations of use of chemical and biological weapons between nations and to assist in the limitation of chemical and biological weapons, and disarmament. The technical resources of WHO¹

¹ An example of such technical resources is the collection of epidemiological information on communicable diseases that has been made by WHO for many years, through its serum banks and its surveillance programmes involving specific diseases. This information provides an invaluable background and potential for determining changes in communicable disease patterns, as well as for obtaining knowledge of diseases already existing in a community. Apart from its general epidemiological value, expansion in the accumulation of such data could be very useful for investigating any possible future allegations of use of biological weapons.

could contribute greatly to the resolution of many of the difficulties that are associated with these problems and are now being discussed within the framework of the the United Nations.

ACKNOWLEDGEMENTS

The Group expresses its thanks and appreciation to the many staff members of WHO who gave valuable help during the preparation of this report. Acknowledgement is also made to the Stockholm International Peace Research Institute, the Pugwash Organization, and the World Meteorological Organization for their collaboration and for supplying much useful information.
