Federal and State health authorities and representatives of State medical societies met during March and April 1955 to consider the health problems involved in protecting the civilian population from the effects of modern weapons of war. The conferences, which were held in each of the nine regions of the Department of Health, Education, and Welfare, were conducted by the Public Health Service in cooperation with the Association of State and Territorial Health Officers, the Federal Civil Defense Administration, and the American Medical Association. Emphasizing that it expects to discharge its civil defense responsibilities to the very best of its ability, the Public Health Service reported its existing plans and activities and presented current facts related to defense against biological, chemical, and radiological warfare. An important objective of the conferences was to secure advice from the States as to how the Service can best help them in providing the health services needed in civil defense. One of the conference papers is given here in full, and five others are given in brief. A seventh paper, a discussion of biological warfare defense by Keith H. Lewis of the Robert A. Taft Sanitary Engineering Center, was omitted from this summary. A glossary on radiation terms appears on p. 192.

Biological-Medical Considerations in Atomic Defense

By EDWIN G. WILLIAMS, M.D., and SAMUEL C. INGRAHAM II, M.D., M.P.H.

THIS discussion of defense against atomic attack centers around atomic radiation, as distinct from the blast and heat effects of a nuclear reaction. Right at the start, we need to pause for a moment to gather some perspective on the problem of radiation from a nuclear weapon. As stated in a recent Federal Civil Defense Administration publication (*1*):

"A surprise daylight attack with a nominal bomb [20 kilotons] exploded at 2,000 feet over an 'average' metropolitan area would produce a total of about 120,000 casualties—killed and injured.

"Of this total, 40,000 (33⅓ percent) would either be killed outright or would die the first day. . . . Thus, probably 80,000 casualties (66⅔ percent) would survive the first 24 hours. Of these 80,000 it is estimated that:

48,000 (60 percent) would be suffering from burns;
40,000 (50 percent) would be suffering from mechanical injuries;
16,000 (20 percent) would be suffering chiefly from radiation injuries."

NOTE: The total exceeds 100 percent because many of the casualties would be suffering from two or more types of injuries.

Thus, we see that radiation injuries are expected to constitute only a small percentage of

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the total injuries caused by an atomic bomb attack. But treatment of burns and traumatic injuries, from which 80 plus percent of the casualties would be suffering, are a well-accepted part of orthodox medical practice; so, albeit somewhat arbitrarily, we are disregarding the vast problems of these injuries. Radiation injuries, on the other hand, are novel to many physicians, and for most nonmedical people they carry an aura of absolute mystery. For this reason alone, we shall limit this discussion almost exclusively to the radiation aspects of nuclear weapons.

The increasing size of atomic explosions and the development of hydrogen-fusion bombs with the power of millions of tons of TNT have recently increased probability of radiation injury from nuclear weapons. The following information, based on an official release of Chairman Louis L. Strauss, Atomic Energy Commission, was published recently (*2*):

"Fallout from [a] hypothetical H-bomb dropped on Washington, D. C., . . . could cause deaths as far as New York City, 220 miles away. In [a] 10-mile-wide circle everything would be wrecked by blast. Heavy chunks of radioactive debris would rain down. But lighter debris and dust would be blown 80,000 feet high. Assuming . . . that winds are northward [which the prevailing winds are], the dust cloud would drop its radioactive cargo in [a] cigar-shaped zone about 220 miles long and over 20 miles wide. Radiation, decreasing with distance from the blast, would be nearly 100 percent lethal for unprotected persons out to 140 miles from ground zero [these days it really is '*area zero*'], diminishing to 50 percent lethal between 140 and 160 miles away, and dropping from 10 percent lethal to safe between 160 and 220 miles away."

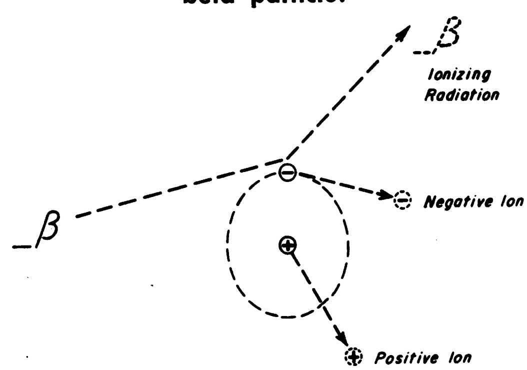
Contrast this radiation effect to that of an atomic bomb, where the expected number of persons disabled by radiation is relatively small. The fallout from hydrogen bombs could affect many millions of people. In certain population areas, several million could be exposed to a lethal dose.

Now, with another reminder that radiation comprises only one phase of the medical problem in atomic warfare, we shall consider pertinent biomedical effects of radiation.

How Radiation Affects Tissue

Atomic radiations, whether they arise from nuclear weapons, from radioisotopes or radium, or from radiation-producing machines, share one distinctive property: During the process of absorption in the body, they all interact with tissue by splitting atoms and molecules into pairs of electrically charged fragments called ions (fig. 1).

Figure 1. Ionization of a hydrogen atom by a beta particle.



The remarkable effectiveness of atomic radiations in causing biological injury stems from their property of acting directly on the individual atoms and molecules composing tissue. By their ionizing effect, radiations may eject electrons from atoms, break up chemical compounds, displace atoms in organized molecules, generate toxic substances and, in general, cause important changes in the submicroscopic structure of body cells.

The potency of radiations may perhaps be appreciated more concretely if one compares, for example, the power of alpha particles (to ionize and injure molecules) with the power of shotgun pellets (to injure people). Relative to their respective targets, alpha particles are 28 times heavier than No. 5 shot (fig. 2). And the speed of 1-Mev. alpha particles exceeds the muzzle velocity of No. 5 shot from a 12-gauge shotgun by well over a quarter of a million times. A shotgun fired at a man can injure or kill him. Alpha particles striking tissue can ionize its molecules and injure or kill its cells. A single shotgun pellet, if it strikes a vital spot, can be fatal. A single alpha particle (or for that matter, any other single radiation), if it ionizes a critical molecule, can kill a cell or possibly start a cancer.

The specific injury produced by radiation in any given circumstance probably depends on many variable factors, such as the density of ionization, the kind of tissue irradiated, and the kind or location of the molecules affected. Observed injuries include the mutation of genes, inactivation of enzymes, inhibition of cell division, and fatal disturbance of tissue functions.

So far as we know, there are four possible results of exposing a living cell to radiation (fig. 3). The cell may be killed. It may be crippled, transiently or permanently. Or it may merely have nonessential molecules ionized and, therefore, actually not be harmed at all by the radiation. Symptoms of radiation injury (skin erythema, radiation sickness, decreased fertility) appear in an individual only after a sufficient number of cells have been injured or killed. Unless the exposure has been sufficient to cause skin erythema, there may be no immediate external warning that a sublethal or even a minimum lethal dose of radiation has been received. Some changes appear early. Others may be seen only after prolonged periods of latency. Evidence of injury from minimal doses of radiation may not show up for months or even years.

The recognizable changes produced in cells by radiation are of many sorts. They include changes in permeability of the cell membrane, changes in the staining characteristics of cells, changes in viscosity of the protoplasm, changes in chromosomes, swelling of cellular components, production of abnormal cell divisions, distortion of cell structure, and many more obscure but measurable changes.

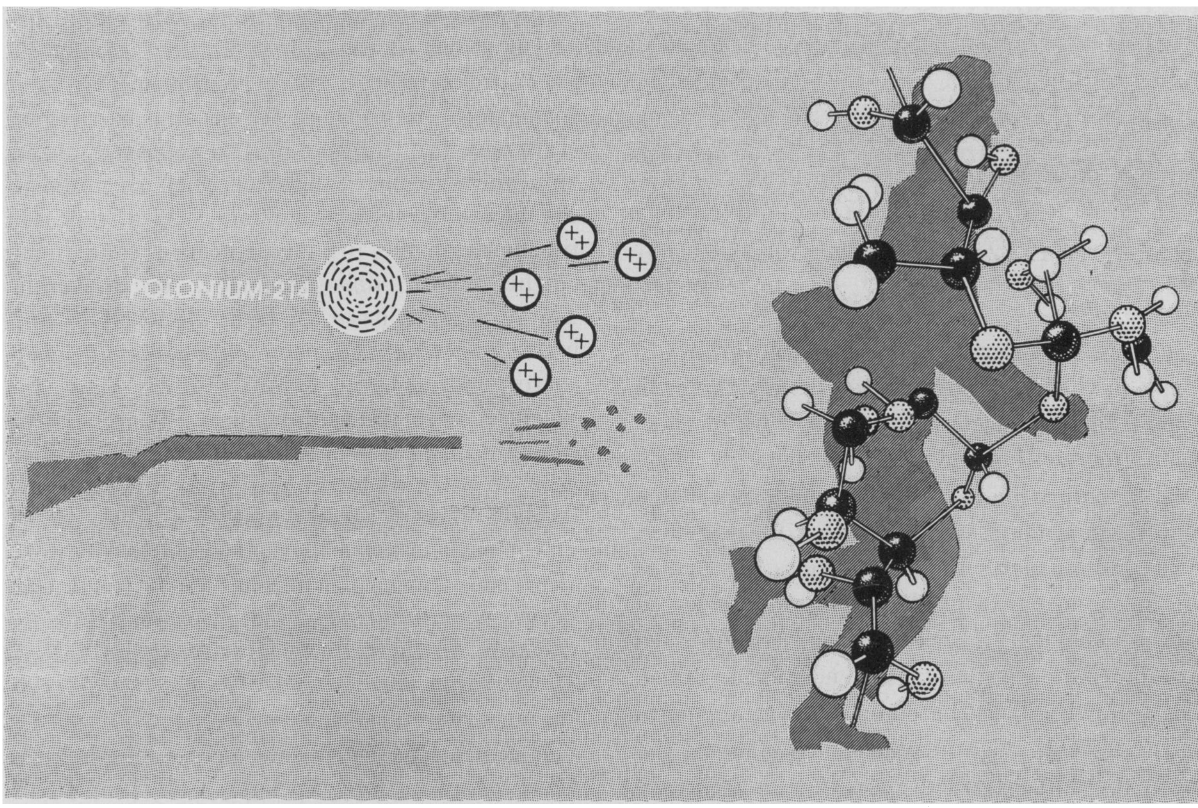


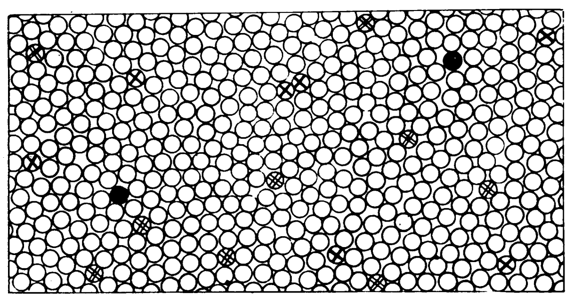
Figure 2. Comparison of the power of alpha particles to injure a molecule with the power of shotgun pellets to injure a man.

Variations in Radiosensitivity

Each of the human body's many different tissues responds differently to radiation exposure. The responses, in general, are a summation of the responses of the various cells and cell types composing the specific tissue.

Rapidly growing or metabolizing tissues are usually more sensitive to radiation than are quiescent tissues. Lymphocytic tissues (lymph nodes, tonsils) are more easily affected than are muscle or nerve tissues. Tissue cells in an organ are more easily injured by radiation than tissue cells grown in a culture.

Figure 3. Diagram of irradiated tissue.



Tissues so differ in reaction to radiation absorption that it is possible to classify them, in a loose fashion, according to the doses of radiation they will successfully withstand. Any such classification is empirical and, since it disregards important variables other than dosage, is far from exact. Various authors place some of the tissues in a slightly different order of radiosensitivity. However, the principle of specific tissue sensitivity is generally accepted. The following list is based on the available data and represents the approximate response of tissues exposed to divided doses of roentgen rays generated at 200 kilovolts (*3*):

Highly radiosensitive (cells seriously injured or killed by doses of 600 roentgens or less): lymphocytes; bone marrow cells; sexual cells (testicle and ovary).

Moderately radiosensitive (cells seriously injured or killed by doses of 600 to 3,000 roentgens): salivary glands; epithelium of skin; endothelium lining blood vessels; bone (growing); epithelium of stomach and intestine; connective tissue; elastic tissue.

Radioresistant (cells show little damage unless dose exceeds 3,000 roentgens): kidney; liver; thyroid, pancreas, pituitary, adrenal, and parathyroid glands; bone (mature); cartilage; muscle; brain and other nervous tissue.

Quite recently, we have been told that the organ systems most fundamentally affected are the central nervous system, the blood forming organs, and the gastrointestinal tract. Nerve tissues, for example, do not recover from injury as do many other tissues.

The recovery of tissues showing any specific radiation effect is dependent upon the ability of the individual cells composing it to recover and reproduce. This in turn depends upon the dose of radiation absorbed and the types of cells present. The blood forming organs, the skin, the membranes lining body cavities, and the secreting glands may regenerate completely and resume their normal functions. Muscle, brain, and portions of the kidney and eye cannot regenerate; repair of them results only in scar formation. Even those tissues that can regenerate may fail to respond after repeated ionization and so cause conditions such as nonhealing ulcers or aplastic anemia. Also, repeated regeneration may produce cancerous conditions: epitheliomata, fibrosarcomata, or leukemia. These changes have all been observed in animals following radiation exposures at levels corresponding to doses only slightly above the accepted safe limits for man. There are no constant clinical symptoms which can be relied upon to warn of latent radiation injury before the late changes become manifest.

Not only is there marked variation in radiation sensitivity of different kinds of cells and tissues within an individual; there is also some variation in the radiosensitivity of individuals of the same species and even more variation among different species.

If killing power is selected to measure the effect of radiation exposure and if mice are selected as the test animals, it may be demonstrated that as the dose of X-rays given over the entire body increases from 200 to 1,000 roentgens the acute mortality rate from irradiation in successive groups of exposed mice will increase from 10 to 100 percent. In addition, the onset of lethal effect will show a latent period which shortens from 8 to 2 days or less as the radiation dose is increased.

If the dose of radiation that within 30 days will kill 50 percent of the individuals exposed (median lethal dose or LD_{50}) is selected as a measure of the biological effect of radiation, the variation in radiosensitivity from animal species to animal species becomes apparent. The approximate LD_{50} X-ray doses for several of the more common experimental animals (based on actual experiments) and the estimated median lethal dose for man (based on animal experiments, reactions of X-ray therapy patients, and data collected in Japan) are as follows:

Animal	*Dose (roentgens)*
Guinea pig	175–250
Dog	325
Goat	350
Man	400–450
Mouse	530
Rabbit	800
Rat	825–900
Weevils	1,000–2,000
Molds	2,000
Bacteria (nonspore forming)	1,500–2,000
Bacteria (spore forming)	20,000–50,000
Viruses	50,000–1,000,000

The potency of radiation to injure tissue is possibly better appreciated when one realizes that 1 roentgen produces about 1,000 ionizations among the atoms in each body cell exposed. Since the adult human body is composed of about 140 trillion cells, this means that exposure of the whole body to the maximum permissible dose for radiation workers (0.3 roentgen per week) will result in about 7 quadrillion ionizations per working day in the body. The human LD_{50} dose (450 roentgens) will ionize about 1 atom in every 100 million in the body, or about 450,000 atoms per cell, on the average.

Effect on Life Expectancy and Fertility

Experimental observations of many different species indicate that radiations induce an aging and debilitating effect. Each roentgen of exposure probably shortens life expectancy of an animal by about one ten-thousandth. This implies that an exposure rate of 0.4 milliroentgen equivalent physical per day (about what man receives from cosmic and other naturally occurring radiation) may shorten the expected life span of a human being by about 4 weeks, if the effect of radiation in man is like that in animals; or 50 roentgens of exposure may shorten the expected human life span by as much as 18 weeks. Also, radiation exposure induces an increased susceptibility to infection.

There is a wide range of specific radiation effects from a wide range of doses. In general, the larger the dose, the more prompt and dramatic are its biological effects; the smaller the dose, the more delayed and more insidious are its biological effects.

In every discussion of the effects of ionizing radiations one of the first questions put to the physician is, "Will it make me sterile?" In response, the physician usually finds it necessary to distinguish between potency and fertility. No direct effects on potency have been reported. Fertility has been affected.

Permanent sterilization of the human female requires 400 to 600 roentgens delivered to the ovary. Sterilization of the human male can be produced by 800 to 1,000 roentgens delivered to the testes. Either of these doses given as whole-body radiation would probably be lethal to the individual, and so danger of causing permanent sterilization by single whole-body exposures becomes a theoretical rather than a practical question. Reduced fertility and temporary sterility have been induced in human beings by single exposures of 200 to 300 roentgens to the gonads and in animals by repeated exposures of as little as 1 roentgen per day for a number of weeks.

A survey a few years ago found that the average number of children born to a group of radiologists was 1.7, whereas the average number of children born to a comparable group of physicians not engaged in roentgenology was 3 (*4*). Inasmuch as the major difference between the two groups of physicians, so far as could be determined, was the practice of roentgenology, these data may indicate a reduction in human fertility from repeated exposure to relatively small doses of X-rays.

Effect on Genes

Genetic, or hereditary, changes may arise from doses of radiation much smaller than those needed to affect fertility. Many genetic experts believe that *any* amount of ionizing radiations may produce hereditary changes cumulative throughout the lifetime of the germ plasm line that can and will appear in future generations. There is, however, no current evidence that radiation workers (X-ray technicians, radiologists, atomic workers) who have not abused the maximum permissible dose limits have produced offspring differing from those of the general populace.

Specifically, from the human genetic studies being made of the completed pregnancies among the surviving victims of the atom bombings at Hiroshima and Nagasaki, at least one positive finding has been reported. The expected normal male-female ratio has been upset among offspring of women exposed within 2,000 meters of ground zero (the point immediately beneath the exploding bomb) by a statistically significant decrease in male births (*5*).

Ionizing radiation can alter the genes in the body (somatic) cells and in the reproductive (sexual) cells and so cause them to grow or reproduce abnormally. If a gene change occurs in a sexual cell, a mutation will occur in later generations provided that the cell is used in reproduction. If a gene change occurs in a cell of growing or regenerating somatic tissue like skin, liver, bone, or bone marrow, it may cause cancerous or other harmful changes in the exposed individual.

Both somatic and sexual cell mutations produced by radiation have been observed in human beings. Statistically significant increases in numbers of mutations have occurred in offspring of parents with a history of exposure to either acute or chronic radiation. An increased incidence of cancers has been recorded in people exposed to amounts of radiation similar to those that produce genetic mutations or cancers in animals. Peller and Pick (*6*) in 1952 reported that among physicians in the United States, there were 8 to 9 times as many fatal cases of leukemia among radiologist physicians as among nonradiologist physicians.

The probability that a cell may be ionized increases in proportion to the number of cells exposed to radiation. As there are many more somatic cells than sexual cells in the human body, somatic cells are the more likely to be changed genetically from a given whole-body exposure. Thus, from the point of view of radiation-produced gene changes and their effects on human beings, one probably should avoid needless radiation exposure at least as much for his own health protection as for the genetic protection of his progeny.

A Calculated Risk

In the civil defense program, we must think of radiation exposure in terms of calculated risk. Exposures ought to be held as low as possible, but doses permitted must allow for such exposures as are unavoidable in accomplishment of essential missions.

No predetermined dosage schedule can be set, in advance of an emergency situation, that will evaluate the relative importance of a given civil defense mission. This evaluation is a command decision to be made by the responsible civil defense official on the spot, at the time. However, one guide in such decisions will be the following data on radiation effects, which were compiled for the FCDA:

Dose (roentgens)	*Observed effects*
0–25	No obvious injury. An average person receives 10–20 roentgens over a lifetime from naturally radioactive sources.
25–50	Least clinically detectable exposure—possible blood changes but no serious injury. 50 roentgens in 1 day is safe if not repeated too soon.
50–100	Blood cell changes, some injury, no serious disability. 100 roentgens causes sickness to approximately 10 percent of the persons receiving this dose.
100–200	Injury, possible disability, probably no deaths. 150 roentgens causes sickness to approximately 25 percent.
200–400	Injury and disability certain, death possible. 200 roentgens causes sickness to approximately 50 percent, death to approximately 2 percent. 300 roentgens causes death to approximately 20 percent.
400–450	Fatal to 50 percent of persons exposed; death occurs within 2 to 12 weeks.
600 or more	Lethal dose causing death to nearly all persons exposed within 2 weeks.

As with other biomedical values, there is nothing magical about the roentgen values given here. The several effects listed merge gradually one into the other as the dosage increases; so, if another table shows slightly varying values, one should not consider this or that table correct and the other one wrong. Rather, the differences will probably be an expression of the normal range of values seen in any biomedical situation.

Among atomic bomb casualties there will be many with multiple injuries. Dual or triple modes of injury may be the rule rather than the exception. Victims may have burns, traumatic injuries, and radiation injuries in any combination. Prognosis in each case will depend on the types and extent of the injuries. Those with radiation injuries in addition to more orthodox injuries will tend to have a graver prognosis than those not having radiation injuries. The reason for this is that one of the important effects of whole-body exposure to atomic radiation is to impair the effectiveness of body mechanisms responsible for resistance to infection and disease and for healing and repair of injured tissues.

Radiation exposure incurred from the atomic flash is, of course, practically instantaneous. That from radioactive fallout, because of the rapid decay of this material, should be thought of as being suffered within a quite short time span: More than 80 percent of the radiation dose from atomic debris will be delivered within 10 hours of the explosion time. The radiologists tell us that radiation exposures delivered over a time span of minutes or hours may be thought of as having effects identical to an instantaneous exposure of the same roentgen value. On the other hand, exposures incurred over a period of days or months have less total biomedical effect on the body as a whole than would the same cumulative roentgen dose if it were delivered over a period of only hours or minutes.

Radiation Sickness

Radiation sickness is the term used to describe the illness produced by overexposure to atomic radiations. The accumulated evidence indicates that radiation sickness represents a symptom complex which may be divided into the following five groups:

1. *General symptoms:* Headache, vertigo, debility, abnormal sensations of taste or smell.
2. *Gastrointestinal symptoms:* Anorexia, nausea, vomiting, diarrhea.
3. *Cardiovascular symptoms:* Tachycardia, arrythmia, fall of blood pressure, shortness of breath.
4. *Hematological symptoms:* Leukopenia, thrombocytopenia, increased sedimentation rate, decreased resistance to infection.
5. *Psychic symptoms:* Increased irritability, insomnia, fear.

Not all the symptoms of radiation sickness occur in each patient. Also, the same patient may react differently at different times to similar radiation doses. In general, the greater the radiation exposure, the quicker and more dramatic is the appearance of radiation sickness. For those interested in more details of human and animal responses to radiation exposure, it is suggested that they refer to the voluminous medical and other scientific literature on this subject.

Therapeutic Measures

There are no known specific agents for the treatment of radiation injury. There are no practical prophylactic drugs to temper or avert radiation injury consequent to adequate exposure to radiation. Medical research is continuing in an effort to discover and develop better means of diagnosis, prophylaxis, and treatment for the victims of all types of radiological hazards, including atomic attack.

The recommended therapeutic measures for radiation sickness and its sequelae are almost exclusively symptomatic or supportive in nature. They include:

1. Bed rest plus sedatives to reduce stress demands on the body economy.
2. Therapy to improve nutrition and maintain fluid and mineral balance.
3. Measures to reduce or prevent infection: Antibiotics; aseptic techniques in nursing and medical care with emphasis on mouth and skin hygiene; leucocytic cream.
4. Antishock drugs.
5. Antihistamines (on the theory that shock is precipitated or made worse by histamine produced by the radiation-injured tissues).
6. Antigastric secretants and antinauseants.
7. Antihemorrhagic drugs.
8. Miscellaneous drugs, such as glucose, glucose-saline injections, cholesterol, liver preparations, numerous vitamins, alcohol, insulin, corpus luteum hormone, Congo red desoxycorticosterone acetate (DCA), and ACTH.
9. Blood transfusions.

The opinions about the therapeutic values of these proposed measures are as varied as the number of substances listed.

Attempts at prophylaxis or prevention of radiation injury by pretreatment has been tried in animals with varying degrees of apparent success. Desoxycorticosterone acetate (DCA) has had some favorable effect in delaying radiation death as have cysteine, glutathione, and rutin. Subcutaneous or intermuscular injection of heterologous bone marrow appeared to have success as a radiation protectant for mice. The latest, most hopeful drug being tried is beta-mercaptoethylamine.

Probably the best summarization of present-day treatment measures for radiation sickness is contained in the final paragraph of the Report on the Medical Studies of the Effect of the Atomic Bomb by Dr. Masao Tsuzuki, professor at Tokyo Imperial University and chairman of the medical section of the Japanese National Research Council. Even though this document is now more than 6 years old, Dr. Tsuzuki's statement is still timely:

"The most important measures for the treatment of the radiation injuries is careful protection. All patients are affected more or less by the radioactivity; these must recover by their own vital power. In the cases in which the vital organs are damaged beyond their ability to recover, medical care at the present time cannot help. We may have some hope of recovery as long as any reserve power is remaining because the radiation exposure has occurred only once. We must, therefore, avoid such treatment as whipping a tired horse hastily. In other words, we should not be overconfident in the ability of our medical care. Our aim shall always be a promotion of the natural healing powers."

Public Reaction

Quite as serious as the physical problem of radiation control is the problem of the public's psychological reaction to the use of radiation. Misunderstanding of radiation coupled with fear of the unknown are usually enough to make a public wary of anything connected with atomic radiations. An injudicious warning about radiation may needlessly increase the difficulty of civil defense activities in the presence of atomic attack. On the other hand, it may be an even worse mistake to pay no heed to the hazards. Public health and civil defense workers can meet this issue by viewing radiation in proper perspective so as to establish and maintain measures for protection without doing psychological damage by their attitudes and statements. Once exposure has occurred, little can be done about the injury. It will not improve the situation to alarm or depress those who have been injured.

Radiation constitutes only a portion of the problems created by nuclear weapons. The major companion problems will be care for burns and traumatic injuries plus an enormous task of sanitation and hygiene for the homeless and dispossessed.

REFERENCES

(1) U. S. Federal Civil Defense Administration: United States civil defense. Special weapons defense. FCDA Publication AG–11–1. Washington, D. C., U. S. Government Printing Office, 1950, p. 14.

(2) Facing the fallout problem. Life 38: 24–25, Feb. 28, 1950.

(3) Dunlap, C. E.: Symposium on scientific proof and relations of law and medicine. Medicolegal aspects of injuries from exposure to roentgen rays and radioactive substances. Occup. Med. 1: 237–301, February 1946.

(4) Hickey, P. M., and Hall, E. W.: Report analyzing the results of the questionnaire sent out to radiologists under the direction of the Sex Committee of the National Research Council. Am. J. Roentgenol. 18: 458–462 (1927).

(5) U. S. Atomic Energy Commission: Semi-annual report, No. 11. Washington, D. C., U. S. Government Printing Office, 1952.

(6) Peller, S., and Pick, P.: Leukemia and other malignancies in physicians. Am. J. M. Sc. 224: 154–159, August 1952.

Radiological Defense

Radiological defense is a part of the integrated defense system of this country. It requires the knowledges and skills of specially trained technicians. However, many simple precautions of a nontechnical nature can be utilized to protect the public.

The detonation of a nuclear weapon is accompanied by the physical phenomena of light, heat, and blast and also by instantaneous nuclear radiations. The magnitude of each of these phenomena is proportional to the energy released in the detonation. Since we cannot see, hear, feel, taste, or smell ionizing radiation and radioactivity, they must be detected and their magnitude measured by sensitive instruments.

A great deal of what has been written about the effects of nuclear weapons is summarized in the accompanying chart. Incident thermal radiation on exposed skin will cause a first degree burn if the intensity is 2–3 calories per square centimeter, a second degree burn if the intensity is 3–7 calories per square centimeter, and a third degree burn if the intensity is 8–10 calories per square centimeter. An overpressure of more than 35 p.s.i. is required to do bodily harm to a person by blast alone. An overpressure of 19 p.s.i. will damage buildings irreparably; 19–6.6 p.s.i. will cause heavy damage; and 6.6–3 p.s.i. will cause moderate damage. Nuclear radiations released at the time of the explosion do not present a serious hazard beyond the effective range of heat and light. A longer-term hazard is created by the byproducts of the reaction: radioisotopes which fall out of the clouds.

Fallout and Monitoring

As the cloud raised by a nuclear blast carries radioactive dust and debris aloft, this matter is swept out by shearing winds. The constituents of the cloud from a large thermonuclear weapon are as radioactive as millions of tons of radium. Fallout contains many species, or kinds, of radioactive materials, each of which decays at its own specific rate. Decay means that the atoms change to other elements; in the process radiations are released. The apparent radiation released by the fallout during the decay process is actually the sum of the radiations released by each individual radioisotope present. Both the decay rate and the intensity of radiation released in the decay process are indicated by the half-life of the material. The half-life is the time required for one-half of the atoms of a given material to decay. The shorter the half-life, the faster the decay and the greater the intensity of radiation produced by the decay process.

To monitor, or measure, the extent and magnitude of radioactive fallout, trained personnel use radiation detection instruments. Monitoring by plane is recommended in the early stages; ground monitoring should follow. The area contaminated by a fallout may be larger than 10,000 square miles.

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Estimating the Hazard

The half-lives of the radioactive materials in the atomic cloud range from a few seconds and minutes to thousands of years. The fallout will contain many radioactive species, some of which can be an internal hazard if admitted to the body, and all of which can constitute an external hazard when outside but in the vicinity of the body.

Estimates of the amount of radiation which a person might receive while in a fallout area are based on an empirical relationship between the initial intensity of the radiation from all the fallout materials, the time elapsed between the detonation and the start of exposure, and the length of time in the area.

As soon as the aerial monitoring crew can furnish a reading of average radiation intensity for an area or as soon as the ground monitor can give an average radiation intensity for a street, block, or even a room which has been contaminated with fallout, it is possible to calculate the intensity of radiation in that locality at any future time, providing, of course, that no decontamination procedures are used and no additional contamination occurs. Tables, curves, and slide rules are available from which solutions to the problem can be read directly.

If the intensity of radiation remains relatively stable, as it does in the vicinity of long half-life radioactive materials, such as radium, uranium, or plutonium, the total dose of radiation can be determined simply by measuring the radiation intensity with an appropriate instrument and multiplying the result by the exposure time. When the intensity is on a sharply declining scale, as it is in a fallout area, probable exposure can be estimated by means of calculus. Tables, curves, and slide rules are also available for obtaining solutions to this problem directly.

Decontamination

Radiological decontamination is still an unrefined science. Wise counsel is to avoid contamination if possible.

There is no practical way to destroy radioactivity. Since radioactive decay is entirely unaffected by physical or chemical reactions, decontaminating solutions such as those used in neutralizing mustard gas contamination are of little value against radioactive materials. The objective of radiological decontamination is to free an area from persistent radioactive agents. This necessitates removal and segregation of microscopic quantities of induced radioactive isotopes, fission products, and unfissioned parts of the bomb fuel.

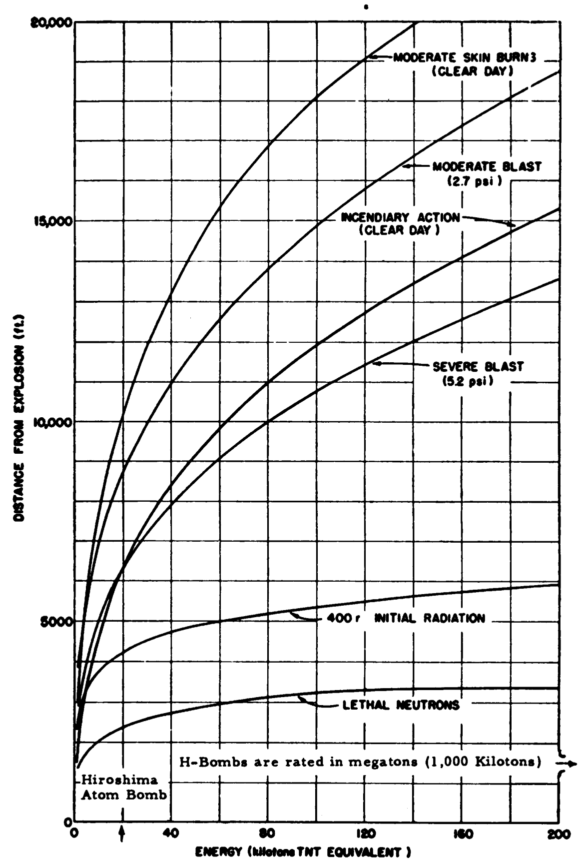
Currently accepted principles of decontamination suggest the following procedures:

1. Immediate reduction to a minimum of that contamination of personnel and vital installations which cannot be or has not been avoided, by means of (*a*) complete bathing, monitoring, reclothing, administering of medical treatment when required, and evacuation of affected personnel; (*b*) washing and scrubbing down exposed surfaces to free them of loose contaminating particles; (*c*) temporarily covering short-range emitters (alpha or beta) with a coating, such as paint, to provide a partial shield against the emissions and prevent the spread of contaminants.

2. Subsequent thorough decontamination of areas important enough and of low enough radiation intensity to warrant such action, which may include (*a*) repeated scrubdowns; (*b*) removal and collection of closely adhering particles by using such chemicals as citric or hydrochloric acid, which make the particles more soluble; (*c*) removal and segregation of the surface to which the particles cling by using paint-removing solutions, scraping, or possibly wet sandblasting (if the surface material can be gathered for segregation).

3. Prevention of the spread of contamination, which may be accomplished by (*a*) preventing access to particularly "hot" areas; (*b*) using great care in disposing of grossly contaminated objects and the water and materials used in removing contaminating particles; (*c*) carrying out a carefully prescribed ventilation doctrine in air-conditioned shelters; (*d*) improvising a change station or decontamination center for the thorough decontamination of personnel and

Distances from explosion at which various effects are produced as function of bomb energy.



their clothing and equipment (clothing may have to be buried).

The value of the operations mentioned in "1" and "2" should always be weighed against the possibility of temporary or permanent abandonment of the area or installation or the possibility of prescribing maximum periods of working time therein.

Salvaging Food and Water

Food in the damaged area may contain some induced radioactivity, but it is unlikely to be present in hazardous amounts. The largest source of contamination is fallout. Radioactive dusts may be deposited on foods or in water.

With respect to food or water that may be seriously contaminated, remember that radiation is less of a hazard when the source is outside the body than when it is within the body. Decontamination or shielding of the skin is far easier than decontamination of the lungs, liver, or bones.

To prevent accidental ingestion of radioactive materials, isolate all unpackaged foods that were located where the dust from a ground burst or mist from an underwater burst might have settled on them. Before opening canned or bottled foods, wash the outside of the container thoroughly. Also scrub all cooking utensils and tableware exposed to radioactive dust or mist. Foods and utensils in tightly closed drawers or cupboards will not be contaminated by fallout.

Water inside household pipes at the time of the explosion will probably not be seriously contaminated. If pressure is available, a little water can be drawn off immediately after the burst and placed in clean containers with covers. This water will be safe for consumption. Although the chances that the city water supply will be radioactive are pretty slim, be cautious about using tapwater for drinking thereafter. If possible, wait until official word is received that the water is safe.

General Information

All radiation is damaging and should be avoided whenever possible. In time of disaster, standards of permissible radiation tolerances will have to be changed from peacetime to emergency levels. The amount of exposure to radiation will have to be weighed against the necessities; that is, it will be a calculated risk. If protective practices are observed, however, the chances of survival will be increased.

Alpha, beta, and gamma radiation will not cause foods, water, or the person to become radioactive. Neutron flux may induce some radioactivity, but everything within the neutron range will probably be damaged beyond recovery by blast and heat. Radioactivity in foods, water, or the body is the consequence of deposits of radioactive elements produced by nuclear reaction.

Because radioactivity cannot be liquidated, the handling of people or objects contaminated with radioactive materials is somewhat different from the handling of people or objects contaminated with any other type of dust. If a person handles people or objects contaminated with radioactive materials, he himself will not become radioactive, but some of the radioactive dust may attach itself to his clothing or body. Decontamination usually takes the form of scrubbing with soap and water. However, since you can't destroy radioactive materials, the wash water must be so disposed of as to guard against entry of the materials into the water supply.

In regard to shelter and shielding from radiation resulting from radioactivity in the fallout area, as long as we can prevent internal contamination, we need consider only gamma radiation. Assuming that the shelter is beyond the range of the instantaneous gamma radiation produced by a 15-megaton weapon, the following tabulations, prepared by Dr. R. E. Lapp, show the extent of the fallout areas that may be expected from this weapon, the average intensities of radiation in these areas, and the corresponding attenuation of radiation that may be expected from shielding material:

Time after burst (hours)	*Fallout area (square miles)*	*Average intensity of gamma radiation (roentgens/hour)*
1	250	2,500
3	1,200	200
6	4,000	30

Reduction factor	*Concrete (inches)*	*Packed soil (inches)*
10	6	11
50	11	18
100	13	21
1,000	19	30

It has been reported that a dose of whole-body radiation of 600–700 roentgens received in a short period of time would be fatal to all recipients. An unprotected person in the 250-square-mile area 1 hour after the atomic explosion would receive this radiation dose (625 roentgens) in 15 minutes. However, if a person were behind 30 inches of packed soil or 19 inches of concrete, the radiation intensity would be reduced by a factor of 1,000 and he would receive radiation only at the rate of 2,500/1,000, or 2.5, roentgens per hour. This dose rate would diminish with time, and the chances are that the person behind this shield would not suffer serious effects from the exposure.

Chemical Weapons

PHR brief

The threat of the employment of poison gas as a weapon of war presents a problem which cannot safely be ignored by either military or civil defense planners. This fact is well recognized by the military staffs of all major powers, and it has always been an important consideration in the civil defense programs of the European countries.

Prior to World War II, it could perhaps be accepted that the logistical requirements of long-range air attack with the then known toxic agents provided a margin of safety for the United States. Except for the doubtful event of an enemy securing a beachhead on our shores or in some nearby territory, it seemed unlikely that the citizens of this country would be exposed to the cyanides, the mustards, or the phosgenes.

Developments during and since the war have completely changed the situation. The emergence of the nerve gases, sometimes called G agents, as toxic agents produces a threat to people located anywhere that a plane or guided missile can reach. These agents are in the possession of both democratic and Communist forces. And the extreme lethality of these new organo-phosphorus compounds meets all the logistic requirements for long-range attack. Nerve gas is a killing and disabling instrument—make no mistake about that—and it produces these effects with relatively minute quantities compared to the older compounds.

Effects of Nerve Gases

Nerve gases, either in the liquid state as loaded in munitions or in the vapor state following shell or bomb detonation, are colorless and virtually odorless. In the vapor form they may attack through the eyes, or they can be inhaled or ingested. In the liquid form they can be ingested, or they may attack systemically through the unbroken skin. The symptomatic effects usually follow this sequence: contraction of the eye pupil, tightness of the chest, labored breathing, nausea and diarrhea, muscular twitching and convulsions, and rapid death unless countermeasures are taken promptly. Death occurs in a matter of minutes for unprotected individuals exposed to lethal concentrations of nerve gas.

These substances are the most powerful enzyme inhibitors known. A nerve impulse reaching a muscle plate produces acetylcholine from the choline and acetate in the tissue. This acetylcholine, which stimulates the parasympathetic nerve system, is normally controlled by cholinesterase. Nerve gases and cholinesterase react irreversibly in the tissue fluid, permitting the acetylcholine level to build up and causing continual stimulation of the parasympathetic nerve system.

Rapid use of blocking agents, such as atropine salts, is required to nullify the effect of the acetylcholine. The atropine salts, usually in the form of the sulfate or the tartrate, are made in ampins or syrettes containing 2 mg. each. Atropine self-injection devices for treatment of nerve gas casualties are being stockpiled by the Federal Civil Defense Administration.

Following exposure to a nerve gas attack, it is recommended that, if pupillary contraction or difficulty in breathing is encountered, an injection of atropine be administered at once. If the symptoms progress rapidly to the convulsive stage, two more injections of 2 mg. each should

By Harry P. Kramer, M.S., chief of the Training Section, Robert A. Taft Sanitary Engineering Center, Public Health Service, Cincinnati, Ohio.

be given immediately. An unconscious person should receive three injections, totaling 6 mg. of atropine, followed by artificial respiration.

Because of difficulties associated with self-treatment, it may be advisable to recommend to the public that atropine injections be given by someone else whenever possible. However, in the event of a successful gas attack, affected persons within the zone of the gas cloud, including those in the impact area and downwind, must be treated promptly to prevent death.

Detection and Identification

Special kits have been developed by the Chemical Corps of the Army for detecting and identifying chemical agents encountered in the field and for collecting samples for laboratory identification.

If used overtly, chemical agents probably would be disseminated in the form of a cloud set up by aerial attack. We would expect the nature and extent of this cloud to be defined by trained civil defense workers using equipment identical or similar to that employed by the military for detection and identification. Areas contaminated with liquid nerve gas must be clearly marked with warning signs or tapes, since toxic vapor will rise for some time after the actual missile explodes.

Chemical agents might also be used covertly—to contaminate our water or food supplies, for example. Kits have been developed for detection of contaminants in these media, and it is planned to train civil defense public health workers how to use such devices and how to interpret the results.

Defensive Measures

The havoc a gas attack is capable of producing must receive serious consideration in our civil defense planning. Certainly to ignore these weapons would increase our vulnerability. The use of nerve gases against an ill-informed and unprotected public would create hysteria and panic almost beyond the imagination. Without gas masks or gas-proof shelters, the casualty rate would be enormous.

A gas mask is the only sure protection against nerve gas or any of the other toxic agents that might be used. At the request of the Federal Civil Defense Administration, the Army Chemical Corps is developing an effective gas mask for use by civilians. The result of several years of research, this mask has several new features. No cannister is used, for example. Instead, there is a so-called diffusion board. One breathes through the sides of the mask rather than through a device attached to the sides or bottom. The mask will have to be made in various sizes to accommodate individual faces. The estimated cost is slightly more than $2.

Already available is another type of gas mask, which is the approved model for civil defense workers. It is a heavy duty type, very similar to the military mask, for use by rescue and monitoring personnel.

A device to protect preschool-age children and babies, who cannot be fitted with a gas mask, is being developed.

Poor shelter from a gas attack is afforded by ordinary enclosed spaces, such as rooms or buildings. In fact, the danger may increase in such spaces after the cloud passes, since residual concentrations may be trapped within the enclosure. Both exposure time and concentration of the substance are important factors, particularly for agents, such as the nerve gases, which the body cannot detoxify. The same effect may be produced by halving the concentration and doubling the exposure time, for example.

Sealing off openings and cracks in a shelter will help prevent penetration of the vapors. Group shelters from which contaminated air is excluded by filtering devices are feasible.

In summary, modern chemical weapons are extremely toxic and can be delivered upon critical targets in our country. Their physiological action produces characteristic symptoms at such a rapid rate that recognition of the early symptoms serves as an effective means of detection. Protective equipment can be produced. But, until and unless this equipment is available—and it is not today—the United States presents a most attractive target for mass casualty attack with nerve gas. Postattack therapy is possible but of little value without protection for both casualties and first aid personnel.

Biological Hazards

PHR brief

Civil defense responsibilities in connection with communicable disease control are so closely related to peacetime activities that major differences exist primarily in emphasis. We have made much progress in the continuing battle against communicable diseases. In a disaster, however, conventional protective measures are likely to be impaired. There is also the possibility of deliberate introduction of disease agents, which may be considered as an adaptation, or perversion, of naturally occurring biological attacks.

Thus, the Public Health Service Communicable Disease Center is able to accept its responsibilities in civil defense by extending and increasing its normal operations. This discussion will be directed primarily toward the investigative activities needed to prepare for wartime health emergencies.

Natural Disease Outbreaks

In this country, many of the communicable diseases are held in check by the combined effects of a relatively high standard of living and widely employed public health practices of immunization, water treatment, milk pasteurization, environmental sanitation, and good nutrition. The destruction of shelter, water supply installations, and sanitary facilities, the movement or concentration of large population groups, and the lowering of individual resistance by exposure, inadequate or improper diet, and lack of immunization, all of which may be associated with modern war, could reduce our defenses against disease to a primitive state. Such reduction in our defenses could well be followed by an increase in communicable diseases to epidemic proportions. Hence, we must prepare to maintain as far as possible our present methods of control during wartime, and we must carry on a continuing search for new and more effective procedures.

By Theodore J. Bauer, M.D., chief of the Public Health Service Communicable Disease Center, Atlanta, Ga.

The center's current program includes developmental studies in the form of laboratory and field research intended to provide new or better methods for control of diseases. As these methods are field tested, they are demonstrated in State and local areas. Training or assistance with training is provided for professional health personnel. Also, equipment and personnel are supplied to communities in the event of epidemics or disasters which cannot be handled by local resources.

Such activities are in the direct interest of our survival during wartime. The needs of civil defense demand that communicable disease research also look at the exotic diseases and the old diseases which may well be revived under emergency conditions. Thus, civil defense requires a communicable disease program broadened to include all likely occurrences and intensified so that each unit of the public health system can operate effectively during emergencies.

One of the problems that may arise in wartime is the exposure of the surviving human population to disease transmitted by rodents and by insects, such as blowflies, which are not ordinarily associated with disease transmission. The development of a chemical treatment for carcasses to prevent both fly breeding and rodent feeding would be the ideal means of solving this problem. Preliminary studies in the Savannah laboratories of CDC have established the potentiality of protecting bodies from blowfly breeding by use of certain pesticides. Plans are being developed for testing additional pesticides and for improving methods and equipment used in the application of these substances against both flies and rodents.

Biological Warfare

Certain diseases which may be of relatively little importance in peacetime could assume great significance in biological warfare. Since the majority of biological warfare victims would be those whom the agent reaches directly, it is imperative to know quickly when, where, and what agent was used. Among the most pressing needs in biological warfare defense, therefore, are rapid and effective means of detecting, recovering, and identifying pathogenic organisms in air, water, and foodstuffs—and possibly in the soil.

Because a likely form of biological attack would be through the formation of aerosol clouds containing pathogenic agents, a prime essential of biological warfare defense is the development of methods and equipment to collect these organisms from the air. Ideally, sampling devices should operate on a 24-hour basis. To reduce to a practical minimum the manpower necessary to operate the devices in this fashion, semiautomatic equipment must be developed.

An obvious corollary to improvement in sampling is the need for methods of rapidly identifying organisms which are considered potential biological warfare agents. Serologic methods have shown the greatest promise to date. Ordinary serologic procedures have the disadvantage of requiring fairly large numbers of organisms and hence a period of time for cultivation of the organisms. A current CDC project concerns methods of identifying pathogenic organisms when only small numbers are present. Promising results have been obtained in preliminary studies with fluorescein-tagged antibodies. In this technique, high-titered antiserums, specific for pathogenic organisms which are considered potential biological warfare agents, are developed in laboratory animals. The antiserums are then associated by chemical means with a fluorescent compound. When homologous organisms and fluorescein-tagged antibodies are combined, the organisms will fluoresce under ultraviolet light.

Chemical Warfare

Although communicable disease control would not appear to be directly related to defense against chemical warfare, actually certain principles and activities are parallel. Since 1949, the Communicable Disease Center has been making extensive studies of insecticides, including the organic phosphorus compounds which are chemically related to and produce essentially the same physiological effects as the nerve gases. These studies have included field and laboratory investigations concerned with toxicity of the compounds under varying conditions, detection and prevention of hazards involved in their use, and treatment of workers exposed to them. Much of the information gained is applicable in civil defense against chemical warfare agents.

Supplementary investigations specifically designed to meet civil defense requirements are needed, however. Problems that should be studied include: development of automatic devices and techniques for rapid detection of nerve gases and feasibility of including such equipment as an integral part of the automatic public warning system; inactivation of nerve gas aerosols by means of counteraerosols or smokes containing mild alkali; effectiveness of protective devices and clothing against nerve gases; persistence of toxic substances on foods and surfaces; decontamination techniques for buildings, clothing, and environment; rapid screening for cholinesterase determinations; and treatment of poisoned persons.

Sanitary Engineering

PHR brief

Civil defense research activities of the Robert A. Taft Sanitary Engineering Center are of the type for which its facilities and staff are well suited. Progress in the projects assigned late in 1954 is summarized here.

Water Supply Protection

Research concerning protection of water supplies has two primary aims: (*a*) to develop feasible methods of reducing the hazards to water supplies from overt or covert attacks with biological, radiological, and chemical agents and (*b*) to develop methods for supplying safe potable water during emergencies.

The plan for accomplishing the first of these aims calls for:

By Harry G. Hanson, M.S.S.E., director of the Robert A. Taft Sanitary Engineering Center, Public Health Service, Cincinnati, Ohio.

1. Evaluation of the hazards to water supply sources of enemy attack with the various special agents.

2. Additional laboratory investigations of the ability of water treatment processes to remove or inactivate various agents.

3. Development of new or improved methods of removing or inactivating these agents.

4. Field trials of the methods developed.

The plan for accomplishing the second aim includes:

1. Determination of needs for emergency water treatment facilities, particularly in areas to which people will be evacuated from target cities.

2. Development of the simplest and least expensive, but reliable, emergency treatment methods.

Several projects already under way are providing valuable information concerning protection of water supplies. One, which is under the sponsorship of the Bureau of Yards and Docks of the Navy, is aimed at developing design criteria and operating instructions for protection of naval continental shore base water supplies from biological, chemical, and radiological agents. We are also studying the ability of existing municipal water treatment methods to remove various concentrations of coliform organisms from raw water; the fate of fallout in the environment after atomic bomb tests; and disinfection materials and techniques. Tentative findings concerning the hazards to water supplies of the various special agents follow.

Biological Agents

A number of biological agents will effectively contaminate water, and the use of these agents by saboteurs is a distinct possibility. Every house connection, every fire hydrant is a possible point of entry by a contaminant. Policing of a large municipal water distribution system to prevent such contamination is out of the question.

The exact quantity of material required to produce an infectious dose of the various biological agents is not known, but it is estimated from limited information on oral infectious doses that 1 to 10 pounds of material would be sufficient to contaminate a million gallons of water. Each cupful of this million gallons would contain an infectious dose.

We see no way of protecting municipal water systems against a determined saboteur. However, we believe that entire cities would not be attacked. It seems more probable that bacterial sabotage would be directed against critical industrial, military, or other particularly vital elements of a city. Re-treatment of water, provision of an auxiliary supply, or storage near the point of use are the only sure means of protecting against such sabotage. Our studies are aimed at determining how much treatment may be needed, whether disinfection alone will suffice, or whether more complete treatment must be provided.

Detection of biological agents in water is likely to be too slow to prevent infection. As yet, too little is known about the normal variation in chlorine residual in municipal distribution systems to warrant use of chlorine residual measurements for monitoring water for presence of contaminants. Visual detection of bacterial contamination is not feasible because of the high concentrations of organisms that would be required.

Knowledge of the ability of water treatment processes to deal with biological contaminants is extremely limited. We know that chlorine in concentrations of less than 1 p.p.m. will deal effectively with contamination by vegetative bacteria if the chlorine is not in a combined form. We know the chlorine requirements for killing the cysts of certain protozoan parasites. But little is known about the ability of water treatment processes to remove viruses or rickettsiae, or the chlorine doses necessary to kill certain spore-forming bacteria, or methods for removing or detoxifying organic toxins.

Chemical Agents

The standard chemical warfare agents are relatively unattractive as intentional water contaminants. The nerve gases, for example, although among the most toxic chemicals known, are considered less of a danger than some of the biological agents. Their toxic effects are exhibited so promptly and so dramatically that their presence would be suspected as soon as a few people had used the water.

Methods for removing nerve gases from water have been developed by the Chemical Corps of the Army and tested by the Corps and the Army's Engineer Research and Development Laboratory. These gases hydrolyze readily at high pH values. Hence, in the event of incidental contamination of water supplies as a result of missiles containing chemical agents falling into the water system, adjustment of the pH to about 10 will lead to the hydrolysis of nerve gases to relatively nontoxic products within a comparatively short time. A method for detecting nerve gases has also been developed by the Chemical Corps, and kits for use in detecting these and other chemical agents in water are available.

The possibility exists, of course, that chemical agents unknown to us are available to an enemy. If other materials do become known, it may be necessary to revise our estimate of the hazard of chemical agents to water supplies.

Development of a monitoring device that will detect any chemical agent and perhaps some toxins may be possible. We are now studying the use of fish, which are much more sensitive than humans to toxic chemicals, as detectors.

Radiological Agents

Although radioactive materials are not considered probable intentional contaminants, there are hazards to water supplies from the radioactive fallout produced by an atomic explosion. Thermonuclear weapons may be detonated at levels which give rise to considerable fallout. However, to what extent these weapons will affect water supplies, we are not ready to say. It is certain that the hazards associated with the use of water contaminated by man-made radioactive elements will not decrease as rapidly as the radioactivity in the water decreases, because the most dangerous of the radioisotopes from the standpoint of internal use have relatively long half-lives. Some water sources may remain dangerously contaminated long after external exposure to radiation from fallout on the ground has declined to tolerable levels.

Additional information on the physical and chemical characteristics of the fallout material is needed to help evaluate the hazards to water supplies. The Public Health Service and others have shown that standard water treatment processes are of limited use in removing soluble radioactive materials. The hazardous isotopes, particularly those of strontium, barium, and iodine, do not respond well to standard water treatment processes. If water supplies are heavily contaminated with these materials, and if the elements are not so closely associated with particulate matter as to be removed with the particles, expensive treatment, such as ion exchange or distillation, will be required to restore safety to drinking water.

Food Protection and Decontamination

One of the first problems following an attack with biological, chemical, or nuclear weapons will be to provide safe food to the surviving population. The Public Health Service shares the responsibility for planning to meet this problem with the Department of Agriculture and the Food and Drug Administration. The Public Health Service area of planning includes the protection and sanitation of milk supplies and other foods in retail markets, restaurants, other public places, and in the home.

Research needs fall into four principal categories: (*a*) rapid procedures to distinguish the nature of the contaminant; (*b*) means for preventing or eliminating contamination by biological and chemical aerosols and radioactive fallout; (*c*) practical decontamination procedures for foods; and (*d*) problems of sanitation and emergency storage of foods needed for mass feeding of displaced persons.

Emergency decontamination of other essential items (food containers or packages, eating and drinking utensils, clothing, and bedding) and of the person and the shelter area is also being studied. Under some conditions and for some items, routine cleansing with soapy water may be the most important phase of decontamination. Information will be obtained on the probable kinds, amount, and persistence of contaminants, as well as the effectiveness of available decontaminants under emergency conditions.

Rapid Identification Methods

We are seeking to adapt membrane filter procedures and infrared spectrophotometry for use in the rapid isolation and identification of bacteriological agents from mixed bacterial populations.

When dried smears of bacterial cells are subjected to infrared spectrophotometry (wave length 5μ to 12μ), characteristic and identifying spectra are obtained. The characteristic absorptions are reproducible within plus or minus 2 percent, provided the bacterial cells are grown under carefully controlled conditions and provided the infrared spectrophotometer is carefully set, balanced, and operated. The spectrographic data can be transferred to punch cards and identification readily established by matching unknowns with knowns. The procedure can be accomplished within a few hours after sufficient bacterial cells are available. At the present time, about 1 mg. of cells is required, but recent developments indicate that satisfactory spectra may be obtained on as little as 0.1 or possibly 0.01 mg. of cells.

Bacterial cells grow on the membrane filter in 10 to 20 hours. The time required depends on the specific organism and other factors. Because the filter is an efficient means of concentrating the organisms from dilute suspensions in fluid or gaseous menstrua and because the organisms grow in situ, membrane filter procedures offer time advantages over conventional fluid or agar media in the production of pure colony growths from mixed populations. By transfer of single colony growths to standard medium, followed by 6- to 8-hour incubations, sufficient pure culture cells for infrared spectrophotometry become available.

We believe that, by using a relatively few (4 to 6) basic differential media, the potential bacterial pathogens can be grown on the membrane filter and tentatively differentiated from nonpathogenic species. Incubation of suspicious colonies on a standard medium for a few hours will supply sufficient cells to allow completion of identification by infrared spectrophotometry. We believe this procedure is capable of detecting and identifying pathogens present in relatively small numbers, even when they are mixed with relatively large numbers of nonpathogenic organisms. The entire process of detection, isolation, and identification could take less than 30 hours.

The available information regarding the detection and identification of chemical agents is being reviewed, with emphasis on the nerve, cyanogenous, mustard, and arsenical gases.

PHS Responsibilities

PHR brief

Prompted by the reasoning that public health phases of civil defense should be "built in" with existing public health programs, the Federal Civil Defense Administration delegated public health civil defense responsibilities to the Department of Health, Education, and Welfare on July 14, 1954. It was felt that the Public Health Service could carry out these responsibilities efficiently and economically through well-established channels. It was recognized, further, that civil defense will be a long-range activity and that it therefore requires continuing program attention.

The following functions have been assigned to the Public Health Service:

1. Plan a national program, develop technical guidance for the States, and direct Federal civil defense activities concerned with research relating to the detection, identification, and control of: (*a*) communicable diseases in man, (*b*) biological warfare against man, (*c*) chemical warfare against man, and (*d*) other public health hazards.

2. Plan, develop, and direct Federal activities concerned with a national program designed to provide Public Health Service reserve personnel from support areas to areas damaged by enemy attack.

3. Plan, develop, and distribute, through appropriate channels, technical guidance concerning the provision of shelter and other protective measures designed to minimize injury to personnel and to reduce damage to vital functional components of public health facilities.

4. Plan a national program, develop technical guidance for States, and direct Federal

By Leroy E. Burney, M.D., an Assistant Surgeon General of the Public Health Service and deputy chief of the Bureau of State Services.

activities concerned with emergency restoration of community facilities essential to health or functional components thereof for which the Public Health Service normally has operating programs.

Planning Assumptions

The Public Health Service civil defense work program for fiscal year 1955 was based on the FCDA planning assumptions for that year. The highlights of these assumptions are:

1. An enemy has the capability of striking any target in the United States.
2. Such attack, if it comes, will consist principally of nuclear (including thermonuclear) weapons delivered by air. These weapons might be delivered by submarines, or they might be smuggled in.
3. Additional weapons, requiring special measures to meet large-scale attacks, will be biological and chemical agents.
4. High-explosive and incendiary bombs are also possible weapons.
5. Preparation must be made to meet psychological warfare and sabotage. Sabotage may include attempts to disrupt industries and communications and covert attacks with biological and chemical agents.
6. The initial attack will be in the nature of an attempted knockout blow, but recurring attacks may be expected.
7. The size of the bombs will range from a few thousand tons to millions of tons of TNT equivalent. One bomb will be sufficient to destroy the largest city.
8. Approximately 1 hour's warning will be received in most areas—possibly less time in some coastal areas and more time in inland areas.
9. Mass evacuation of target cities will provide the best means of reducing casualties.
10. Any area attacked will require outside support; mutual aid will be helpful but it will not be sufficient alone. Both mobile and fixed support from the State attacked, other States, and Federal sources will be required.

We understand that many of the 1955 assumptions, such as the probability that biological and chemical weapons, as well as nuclear weapons, will be used against us, will be carried over to the planning assumptions for fiscal year 1956. However, a major change is expected as a result of the recent Atomic Energy Commission release concerning radioactive fallout from explosion of a thermonuclear bomb. The release emphasized that it is not possible to apply a single fallout pattern to all thermonuclear detonations. This is true even under test conditions, when the bomb size is known, since the nature of the ground where the explosion occurs, the size of the resulting particles, and the variable directions and velocities of the winds at different levels all have to be considered. With adequate knowledge of atmospheric conditions, however, the fallout pattern usually can be predicted with considerable accuracy.

In the Bikini test of March 1954, the area of extreme hazard from fallout was up to 20 miles wide and 140 miles long downwind from the explosion and about 20 miles upwind and crosswind. The area of some hazard extended approximately 100 miles farther downwind and 20 miles farther to the sides.

Outline of the PHS Program

The Office of the Surgeon General has the overall responsibility for civil defense planning and program development in the Public Health Service. In addition, this office is conducting a project concerning the adaptability of military chemical warfare defenses to civil defense needs.

The National Institutes of Health are conducting investigations designed to lead to improvement of vaccines and other immunizing procedures. Some of their research is directed toward the development of better adjuvants and the determination of effects of known adjuvants with different vaccines. They are also studying preparation and evaluation of purified antigens in experimental animals and the effects of combined antigens in reduced amounts. The goal for this year is to determine whether or not combinations of certain antigens will produce adequate immunization in experimental animals and the minimum amounts that will produce satisfactory immunity. (Since the date of the civil defense conferences, this work has been suspended temporarily.)

The Bureau of State Services will keep the

States informed of the results and means of application of all research relating to biological and chemical warfare hazards and other public health problems. Upon request from the States, the Bureau will provide training courses for key health personnel and for trainers, who, in turn, can train others. To the limit of its resources, the Bureau will provide assistance in planning State studies and operations. The Public Health Service regional offices will be the channel between the Public Health Service and the States.

Glossary of Radiation Terms

Alpha particle: Charged particle, having a mass of 4 units and 2 unit positive charges of electricity, which is emitted from the nucleus of some atoms. It is composed of 2 neutrons and 2 protons.

Alpha ray: Stream of fast-moving alpha particles. It is a strongly ionizing and weakly penetrating radiation.

Atom: The chemical unit of which all matter is made. It is the smallest particle of an element capable of entering into a chemical reaction.

Atomic radiation: Radiation produced by energy changes in atomic nuclei or atomic electron clouds; ionizing radiation.

Background radiation: Ionizing radiation produced by cosmic radiation and naturally occurring trace amounts of radioactive elements.

Beta particle: Charged particle, having a mass and charge equal in magnitude to those of the electron, which is emitted from the nucleus of some atoms.

Curie: Standard measure of the rate of radioactive decay; the quantity of any radioactive substance in which the number of disintegrations per second is 3.7×10^{10}. The radioactivity of 1 curie of a substance is comparable to the radioactivity of 1 gram of radium.

Decay: Disintegration of the atomic nucleus of an unstable element by the spontaneous emission of charged particles or protons or both.

Electron: Negatively charged particle which is a constituent of every atom; unit of negative electricity equal to 4.80×10^{-10} electrostatic units. Its mass is about $\frac{1}{2000}$ of that of a proton.

Electron volt: Amount of energy gained by an electron in passing across a potential difference of 1 volt.

Equivalent roentgen: Amount of radiation which produces in air an amount of ionization equal to that produced by 1 roentgen of X-radiation or gamma radiation.

External radiation: Radiation entering the body from without.

Fallout (radioactive or atomic): The radioactive dust and atomic or hydrogen bomb debris that falls to the ground downwind from an atomic explosion.

Film badge: Small piece of X-ray or similar photographic film enclosed in a lightproof paper, usually crossed by lead or cadmium strips, carried in a small metal or plastic frame. It is used to estimate the amount of radiation to which an individual has been exposed.

Gamma ray: Electromagnetic radiation emitted from the nucleus of a radioactive atom.

Half-life: Time required for a radioactive substance to lose by decay 50 percent of its activity.

Internal radiation: Radiation produced inside the body from a radioactive substance assimilated and contained within the tissues.

Ion: Atomic particle, atom, or chemical radical (group of chemically combined atoms) bearing either a positive or negative electrical charge caused by an excess or deficiency of electrons.

Ionization: Act or result of any process by which a neutral atom or molecule acquires either a positive or negative electric charge.

Ionizing radiation: Radiation possessing sufficient energy to ionize the atoms or molecules absorbing it.

Isotope: Any of two or more forms of an element having the same atomic number (nuclear charge) and hence occupying the same position in the periodic table. All isotopes of an element are identical in chemical behavior but are distinguishable by small differences in atomic weight. The nuclei of all isotopes of an element have the same number of protons but differ in the number of neutrons.

LD_{50}: The dose of radiation which will cause death to approximately 50 percent of the members of a given animal species, usually within 30 days; the median lethal dose of radiation.

Mass unit: Unit of mass which is $\frac{1}{16}$ the mass of an oxygen atom taken as 16.00000.

Maximum permissible dose: The maximum dose of ionizing radiation that, in the light of the present knowledge, is not expected to cause appreciable bodily injury to a person at any time during his life.

Microcurie: A millionth of a curie; the quantity of any radioactive substance in which the number of disintegrations per second is 37,000.

Millicurie: A thousandth of a curie.

Neutron: Nuclear particle which is electrically neutral. Its mass is approximately the same as that of a proton.

Nuclear reactor: A device or machine for producing energy by fission or fusion of atomic nuclei.

Permissible dose: A dose of ionizing radiation that, in the light of present knowledge, is not expected to cause appreciable bodily injury to a person in any time during his life.

Proton: Nuclear particle with a positive electric charge equal numerically to the charge of the electron. Its mass is 1.007575 mass units.

Radiation sickness: The group of symptoms developed consequent to an overexposure to ionizing radiation. The symptoms include weakness, nausea, vomiting, diarrhea, leukocytopenia, anemia, and spontaneous bleeding.

Radioactivity: Characteristic of certain kinds of matter, the atomic nuclei of which are unstable and undergo spontaneous disintegration with liberation of energy. The disintegration process, which usually results in the formation of new elements, is accompanied by the emission of one or more types of radiation, such as alpha particles, beta particles, and gamma rays.

Radiosotope: A radioactive isotope.

Radiological health: The public health aspects of the use of ionizing radiation.

SD_{50}: The dose of radiation which will cause radiation sickness to approximately 50 percent of the members of a given animal species.

Approval Withdrawn for Three Food Dyes

The Food and Drug Administration has removed three widely used coal tar dyes from the certification list of approved coloring materials which may be added to food. The law requires that food colors be certified as completely harmless.

The three colors involved, FD & C Orange No. 1, Orange No. 2, and Red No. 32, are harmless in the amounts ordinarily consumed in foods, but recent scientific investigation shows they are not harmless when taken in large amounts.

Orange No. 1 has been widely used in candy, cakes, cookies, carbonated beverages, desserts, and meat products, especially frankfurters. Orange No. 2 and Red No. 32 have been used in coloring the outer skin of oranges.

While manufacturers may no longer label and sell these three colors for food use, all three colors have been added to the list that may be certified for external drug and cosmetic use.

These colors will no longer be certified for internal use after February 14, 1956. The law does not prevent use of stocks previously certified.