Control of Common Radiation Hazards in New York City

LEONA BAUMGARTNER, M.D., and HANSON BLATZ

THE NEW YORK CITY Department of Health has had many years of experience in dealing with certain specific radiation problems. Registration of X-ray laboratories has been required for more than 30 years. A study of and an attempt to control shoe-fitting fluoroscopes and the sale of luminous-dial watches containing excessive amounts of radium have been undertaken. Followup of complaints and inquiries regarding possible misuse or improper installation of medical, dental, and veterinarian X-ray equipment have long been regular activities of the public health sanitarians. Recently, as concern over exposure to radiation has increased, our health department, like many others, has expanded its activities.

Basic Legislation

After a careful study of legislation proposed by various groups, the New York City Board of Health in March 1958 adopted a new section of the New York City Sanitary Code intended to cover all radiation hazards. (With some modification, the radiation code was included in the New York City Health Code (*1*) enacted in 1959.) This code differs from most other radiation legislation in authorizing a fee for registration of radiation sources. Besides helping to finance the program, the fee has, we believe, resulted in registration being taken more seriously. Preliminary meetings were held with radiation experts and with professional and business groups that would be affected to obtain the widest possible discussion and acceptance of the code before its adoption.

The radiation code authorizes use of the widely accepted recommendations of the National Committee on Radiation Protection (NCRP). Its wording is such that future modifications of the NCRP recommendations automatically become part of the code. At the same time, it permits exceptions to the NCRP recommendations or changes in emphasis where incompatibility with any local public health policy might result.

Organization and Staffing

Because of its expected size and its highly technical nature, we decided to conduct the program with a carefully organized and trained staff of radiation specialists whose work would be limited to radiation inspections, rather than to add the work to the many other activities of the sanitary inspectors. As far as we know, only one other State or local radiation control program follows this policy.

An office of radiation control was set up as an integral part of the health department. Field staff were recruited from among those sanitarians in the department who had a college degree in science or its equivalent. The director and assistant director have had extensive experience and training in the radiation field. By special arrangement, the director has been given an appointment in the Environmental Radiation Laboratory of the New York University Institute of Industrial Medicine.

A commitee of technical experts in radiology, radiological physics, industrial hygiene, civil defense, atomic energy, and dental radiology was set up as an advisory group. It was made advisory, however, not to the health department,

Dr. Baumgartner is commissioner of health for New York City, and Mr. Blatz is director of the office of radiation control of the New York City Department of Health.

but to the mayor, since other city departments are also concerned with radiation hazards.

Because of the interest of many city agencies in radiation control, the mayor also appointed an Interagency Council on Radiation composed of the commissioners or other representatives of the fire, police, hospitals, water supply, public works, marine and aviation, and health departments, and the office of civil defense. Coordinating activities are usually carried out by action committees made up of technical representatives of the agencies concerned with specific problems. For example, the Emergency Action Committee consists of representatives of the health, fire, and police departments. Another committee, concerned with possible radioactive contamination of the city's water supply, includes representatives from the health department, department of water supply, gas, and electricity, and the board of water supply (the city's overall water supply planning agency).

The city administrator is chairman of the Interagency Council on Radiation. The mayor's Technical Advisory Committee advises the council, and the health department's office of radiation control gives technical guidance. This combined organization has worked well and has served to avoid duplication of radiation control activities by the various agencies.

Establishment of the office of radiation control has had an additional advantage, that is, improvement in communication with the local press. Reporters have learned that they can quickly get factual information from the director, with the result that newspaper stories are more objective and more accurate than in the past. Not one of several recent incidents involving actual or suspected radioactive materials (for example, recovery of a capsule of radium in a sanitary landfill or disappearance and recovery of a scientific exhibit item containing radioactive material) received scare-type publicity. A few of the incidents were given brief public-interest notices after the cases were solved.

Registration of Sources

Recognizing that accurate knowledge about all sources of radiation is basic to any control program, we began with collection of data on their nature, location, and manner of use. Registration requires completion of a carefully planned questionnaire as well as payment of a $15 fee. The data obtained have been put on punchcards to expedite handling and programing.

From registration data obtained by January 1, 1960, we estimate that there are some 20,000 individual sources of radiation in New York City. Counts of the principal kinds of X-ray machines at registered installations give a total of 16,439 units, as shown in the following tabulation. (The medical units include those owned by podiatrists and osteopaths. A radiographic-fluoroscopic combination unit is listed in both categories.)

	Number of units
Medical fluoroscopes	5,268
Medical radiographic units	4,619
Dental units	6,552
	16,439

In addition, 214 deep therapy installations, 70 veterinarian installations, 416 radioisotope users, and 140 radium users are registered. The actual number of sources at these installations is not yet known, but many of the deep therapy and veterinarian installations have more than one X-ray unit, and the radioisotope and radium users generally have multiple sources. About 8 percent of the radioisotope users and 24 percent of the radium users are industrial.

A breakdown of the registered radiation installations, excluding industrial installations, by owner category is as follows:

	Number of installations
Dentists	6,409
Physicians	5,128
Podiatrists	442
Hospitals	343
Veterinarians	70
Osteopaths	65
Chiropractors	6
Total	12,463

Chiropractors, currently involved in litigation regarding authority to use X-rays, are the only group not registered essentially 100 percent. We estimate that there may be as many as 500 chiropractors using X-ray equipment.

Even though the registration requirement was widely publicized through press and radio and professional and business groups, it took almost a year and a half to attain complete registration. Many hundreds of personal visits and telephone calls were made to those who had not responded to several notices informing them of the need to register. Apparently the difficulty was in communication, for there was little resistance once contact was made. The medical societies requested each member who had not registered to do so; in fact, they as well as the dental societies have approved the radiation control program generally.

The $15 fee covers registration for 2 years. Payment of $10 is required biennally thereafter. In order to keep registration up to date, the radiation code has been amended to require dealers and manufacturers to notify the department of health within 10 days after delivery or installation of radiation equipment. Experience indicates that such notifications are being received regularly.

Establishment of Priorities

The NCRP and its many subcommittees have made hundreds of recommendations applying to a wide variety of radiation sources and circumstances. We decided that, at least for the first few years of the program, we would consider only the mandatory recommendations, that is, those using the word "shall."

Each of the applicable "shall" recommendations was listed, and the potential hazard it was intended to control was evaluated by estimating the likelihood of a radiation exposure occurring if the recommendations were not heeded and the severity of the exposure if it should occur. An estimate was also made of the number of persons likely to be subject to such overexposure.

Reports on radiation exposure in the literature (for example, *2–5*), as well as our own radiation registration findings, indicate that by far the most important consideration in radiation control is the exposure of medical and dental patients during routine X-ray examinations. Of an estimated 20,000 sources of radiation in New York City, at least 16,500 are medical and dental X-ray machines. There are only 416 licensed radioisotope users and 140 radium users, although the number of individual sources of radiation in these categories is considerably greater.

The Federal Radiation Council reported in 1960 that of 66,000 radiation workers employed by AEC contractors, only 17 received radiation doses exceeding the so-called maximum permissible limits (*6*). Of those 17, 12 were in serious radiation accidents that could occur only at certain development laboratories concerned with the design and testing of weapons components or reactor fuel elements. The problem is not the sort with which a local health agency would normally be concerned.

In contrast, estimates of the number of patients exposed to diagnostic X-rays in the United States are of the order of hundreds of thousands a day. Reports by the National Academy of Science (*2*), the United Nations Committee on Radiation (*3*), and the Federal Radiation Council (*6*) indicate that medical and dental use of X-rays constitutes an estimated 96 percent of all manmade radiation to which the population is exposed. These reports also show that this source accounts for an integrated population dose (average per capita dose of genetic significance) estimated to be at least 25 times as great as the total integrated dose to the population resulting from the entire atomic energy industry. Thus, any reduction in exposure to medical and dental X-rays, even though it be very slight, would be much more significant in reducing the total population dose than an equivalent degree of reduction in occupational exposure.

Except for rare accidents or occasional gross negligence, there is little evidence that industrial workers are receiving radiation doses in excess of the conservative limits established by the NCRP. There is much evidence, however, to indicate that many medical and dental patients receive more radiation than is actually necessary for a particular X-ray examination. This does not mean that the number of examinations need be reduced but that each examination be done with equipment and techniques that keep the dose as low as possible. We believe, therefore, that assistance to physicians and dentists in reducing radiation exposure constitutes the most valuable public health contribution in radiation control today. Major attention has been given to this goal in the New York City program.

Medical and Dental Equipment

The recommendations of the National Committee on Radiation Protection relating to medical and dental X-ray equipment (7), now included by reference in the New York City Health Code as rules, concern the unnecessary or excessive exposure of three groups: patients, operators of the equipment, and persons living or working near X-ray installations. As previously emphasized, the first group is certainly the largest, and it is to this group what we have so far directed our major efforts, although some attention has also been given to the other two.

In preparation for the inspection program, the most serious deficiencies in X-ray equipment design, installation, and use were listed, and standards were formulated against which equipment or techniques could be measured. A standard operating procedure and a checklist were developed for inspecting each type of X-ray installation, including medical diagnostic X-ray, medical therapeutic X-ray, mobile or portable X-ray, fluoroscopic X-ray, and dental X-ray installations. All the inspection criteria were reviewed and approved by the mayor's Technical Advisory Committee.

An initial group of public health sanitarians, all with inspection experience, were then taken to the showroom of one of the local X-ray dealers and to one of our largest city hospitals for intensive training in inspecting X-ray equipment. These sessions were supplemented by classroom lectures and demonstrations covering the principles of radiation protection.

Major Deficiencies

So that the most serious hazards can be corrected as soon as possible, each installation is given a preliminary inspection limited to basic faults, and secondary matters are relegated to followup inspections.

The first inspection consists of a visual examination against a standard checklist. No radiation detection instruments are used. A fluorescent screen is used to determine the area covered by an X-ray beam, a very important criterion of the exposure dose. The screen is also used to determine any gross deficiency in shielding; for example, replacement of protective lead glass by a piece of ordinary plate glass. A special gauge for measuring aluminum filter thickness and a tape measure for several other measurements are the only equipment necessary. The checklist covers such items as the size of the X-ray beam used, for example, in chest radiography and in radiography of extremities, filter thickness, distance from fluoroscope tube to panel, limits of fluoroscopic shutters, and relation of the X-ray control and radiographic exposure switch to operator's shield.

The X-ray equipment operator (technician or physician) is asked to demonstrate a few common techniques, mainly to determine what size X-ray beam is used. The inspector acts as the patient, except that no exposure is made. The following beam diameters are used as guides in determining when the beam is larger than clinically necessary:

Film size (inches)	*Film diagonal (inches)*	*Beam diameter (inches)*
8 by 10	12¾	15
10 by 12	15½	17½
11 by 14	17¾	20
14 by 17	22	24

Experience has shown that when these or smaller diameters are used, corner cutoff will frequently appear on exposed films. Absence of such cutoff in all films generally indicates inadequate collimation.

In addition to marking the checklist, the inspector sketches, on the back of the form, a scale drawing of the X-ray room and the location of the equipment and the controls. He also indicates the nature of the occupancy of all adjacent areas. For installations where structural shielding appears to be critical, but where there is no positive evidence that it is actually installed, the inspector notes this fact for a followup test. Inability to measure readily both the fluoroscopic filter and distance from tube to panel or any indication that lead glass or a protective tube housing is inadequate also calls for special notation.

If necessary, a second inspection is made of fluoroscopic equipment to measure the dose rate. This measurement is required, we believe, only when the filter thickness and the tube-to-panel distance cannot be measured or when the voltage and current settings cannot be reasonably estimated. Actual measurements of a sample of the equipment on our list indicates that it is only when these factors cannot be determined that the fluoroscopic dose rate can differ by more than about 25 percent from the value given on standard X-ray output tables.

In choosing which equipment to inspect first, certain priorities were obvious: machines used most frequently (those in large hospitals, for example), machines used with heavy dosage, and machines built before modern safeguards and structural shielding were common. Equipment used in the examination of children and pregnant women will be inspected next.

This streamlining of the program, plus, of course, the geographic compactness of the area, has enabled each inspector to complete five inspections a day. In the first year and a half, more than 4,000 visits have been made by a staff of two or three inspectors. Spot reinspections indicate that these preliminary inspections have led to elimination of many of the most serious deficiencies. The following tabulation, based on 1,000 inspections of dental equipment and 2,500 examinations of medical equipment, shows the extent of three deficiencies.

	Percent of dental units	*Percent of medical units*
Excessive beam size	30	64
Inadequate filter	35	20
Inadequate operator protection	2	51

At first we found that some surgical supply houses (as distinguished from the major X-ray manufacturers, who usually sell directly in our area) were installing medical and dental X-ray equipment that did not meet the basic safety standard or was not being properly installed. The New York City Health Code fixes responsibility for these matters with the seller. Prompt followup has served to inform suppliers of the standards they must meet and has resulted in much improvement in recently installed equipment. For example, we never see an X-ray table and control installed side by side without shield for the operator, although this arrangement was common in the past. The suppliers' responsibility is, we believe, a unique feature of our program.

Structural Shielding

A third inspection is made if the initial inspection report indicates a need for a test of structural shielding, particularly when the shielding is intended to protect adjacent rooms not under control of the owner or operator of the equipment. This test is made by a team specially trained for the job. The recommendations of the NCRP and those of the Federal Radiation Council are quite specific and conservative in limiting the dose to occupants of areas not controlled by the owner or operator of an installation. The very low limit of ½ rem per year has recently been established.

Investigation of structural shielding may present difficulties in public relations. The neighbor sometimes does not know he is located adjacent to a source of radiation, and often he cannot fully understand that even under the most conservative standards there will be detectable radiation in his quarters. It is often desirable, therefore, to conduct such evaluation without entering the neighboring areas. If the adequacy of shielding cannot be determined simply by inspection or by test borings, the owner of the equipment is responsible for proving that shielding has been installed by submitting building plans or some other evidence. Often, where the existence of shielding cannot be proved, the addition of 1 or 2 mm. of lead shielding is preferable to making measurements in the next apartment or building.

At present, we are investigating the feasibility of determining the adequacy of lead shielding by radiation-scattering devices. These instruments have been used for determining soil density, the presence of certain materials under the ground, and the nature of certain unknown materials. We believe that the presence of lead shielding can readily be determined by such a method, but it is not certain that its thickness can be determined with a sufficient accuracy or facility. When access to the adjacent property can be gained, shielding is tested with an iridium 192 source and scintillation detectors.

Radium and Radioisotopes

Proper use, storage, and handling of radium, usually in hospitals, is the second aspect of the radiation control program. Paraphrasing recommendations of the NCRP (*8*), we prepared a guide for radium users. This guide requires the owner to appoint a source custodian who is responsible for a careful accounting system.

He must have authority to approve or disapprove the withdrawal of radium for use, and he must keep a record showing the whereabouts of the material at all times.

Radium users must provide adequate facilities for secure and well-shielded storage of the material, a suitable place for its preparation and cleaning, and appropriate handling tools, shields, and transport containers. We plan soon to institute standard periodic tests for damaged or leaking radium tubes or needles.

These requirements, we believe, will correct the two most common radium hazards: misplacement or loss of the material and leakage of radium or radon gas from damaged units.

At present, the Atomic Energy Commission conducts an extensive inspection program in connection with its distribution of reactor-produced radioisotopes. The health department therefore has felt no major concern for the handling of these materials. However, current negotiations are expected to result in transfer of the licensing and regulation of users of radioisotopes and of small amounts of source materials (uranium and thorium) and fissionable materials in this area from AEC control to local control. This responsibility can easily be assumed by our program with a small addition to our staff.

Radioactive Wastes

Each of the hundreds of users of radioactive materials in the city constitutes a potential source of environmental contamination, either through air pollution or through normal disposal of radioactive wastes. Although there is no reason to believe that either of these is at present a significant source of exposure, both will bear watching. Radioactive contamination of the environment (air, water, or soil) cannot readily be removed, particularly contamination by long-lived radioactive materials.

Our program is currently investigating local waste disposal methods. So far, we have found no practice requiring correction. As the use of radioactive materials becomes more widespread, however, it may be necessary for public health agencies to take a more conservative position regarding waste disposal.

In general, use of radioactive materials in industrial plants in New York is supervised by the State department of labor. The few industrial locations within New York City handling enough radioactive materials to constitute a significant source of radioactive contamination of the air are being kept under surveillance. The Atomic Energy Commission and the State department of labor tell us of any new users in the city.

Transportation of Radioactive Materials

New York City's concern with transportation of radioactive material is unique in the United States, if not in the world. As part of the U.S. program of support for atomic development throughout the world, the Atomic Energy Commission ships much nuclear fuel to other countries and eventually receives all of it back in the form of spent fuel elements that are returned for chemical processing and for the separation of fission products. The spent fuels in particular could constitute a significant hazard if involved in an accident or fire. Fissionable materials in supercritical quantities are also possible sources of trouble if mishandled.

Most of the nuclear fuel shipped out of the country passes through New York City. Several incidents involving this material have occurred in the past few years, usually in connection with its transfer from railroad, truck, or airplane on which it is shipped into the city to airplane or ship for the trip overseas. There were no serious consequences, but many of the incidents attracted widespread attention in the press and caused considerable alarm.

A review of transportation accidents and fires which have occurred throughout the country discloses no evidence that anyone has ever been exposed to excessive radiation as result or that there has been any great damage as a result of radioactive contamination. The risk of radiation exposure resulting from a transportation accident therefore appears slight. Nevertheless, primarily to prevent the public apprehension any such incident would cause, we believe that such city agencies as the fire, police, and health departments should know in advance whenever a hazardous shipment is to be made into or through the city. The health code requires prior notification of all such shipments, as well as notification of any accident, incident, or overexposure in any situation. The Atomic Energy Commission and its various contractors and licensees engaged in the shipment of such materials have given us excellent cooperation in this regard.

Radioactive Fallout

Except for periodic measurements of the amount of radioactivity in our water supply and of external radiation levels, our program has not been particularly concerned with radioactive fallout. The extensive programs of the Public Health Service and the Atomic Energy Commission indicate that, at present, fallout does not constitute a serious public health hazard, in comparison with other sources of radiation to which the population is exposed. We are concerned only with any gross changes in fallout that might indicate the need of a further investigation. If background radiation resulting from fallout were to increase generally, we would certainly learn of it from the national networks. Unless radioactivity does increase very greatly, there is little that a local health department can or should do.

To allay undue public fears, we have put together in layman's language a statement concerning strontium 90 in milk (*9*). This statement has been widely used in answering queries and for distribution to parents' groups and others. Keeping a balance on the hazards of radioactive fallout in combating radiophobia is a challenge to health departments that should be met decisively.

Research and Evaluation

Through its management analysis and research units, the health department is watching the new radiation control program. Eventually, these units plan to develop evaluation indices and performance standards on routine activities.

Close association between the health department and the Environmental Radiation Laboratory of the New York University Institute of Industrial Medicine has made possible more formal research planning than would have otherwise been possible and has proved of mutual benefit to the two institutions. Currently, a joint project, supported by the Public Health Service and undertaken in cooperation with the Sloan-Kettering Institute, is concerned with actual exposures during medical X-ray diagnosis. Arrangements have been made through the local county medical societies to keep accurate exposure records of all radiographic and fluoroscopic examinations for a carefully selected sample of each medical specialty using X-rays. Details as to exact techniques and exposures will be recorded and related to dose measurements in the laboratory on phantoms under conditions as nearly like those of actual use as possible. From these data, integrated tissue dose (the so-called integral dose, in gram-rads), bone marrow dose, and gonad dose per capita as well as average dose per examination can be estimated.

To help evaluate the fluoroscopy records, a subsidiary project is studying exposure during fluoroscopic examinations. Large X-ray sensitive films are used to measure the cumulative dose of radiation entering the patient's body during fluoroscopy by fastening the film to the panel of the fluoroscope prior to the examination. After development, the film is measured on a special densitometer. By indexing the films to the points of reference, such as the hips or shoulders of the patients, the dose to various organs can be determined.

Summary

New York City has developed an extensive radiation control program over the past few years. The program is interdepartmental, with major responsibility vested in the health department. A new section of the New York City Health Code, enacted by the board of health in 1959, requires registration of every source of radiation in the city and notification of hazardous shipments of radiation materials, of all newly installed radiation installations, and of accidents, incidents, and overexposures.

Emphasis has been placed on helping physicians and dentists to reduce to a minimum the radiation dose to patients from X-ray equipment. This source of radiation constitutes an estimated 96 percent of all manmade radiation to which the population is exposed. In our experience, it has been possible to reduce this hazard significantly.

The New York City program has also taken steps to control the use of radium and is preparing to deal with problems of radioactive isotopes, transportation of radioactive materials, disposal of radioactive wastes, and fallout as the need becomes evident.

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Drinking Drivers

A "tough" policy to counteract the flood of traffic deaths and injuries caused by drinking drivers is urged by Dr. Seward E. Miller, director of the University of Michigan Institute of Industrial Health and formerly with the Public Health Service. He says, "We can begin by finding a better word than 'accident.' An 'accident' implies that the event is out of the hands of the driver. But drunken driving is entirely the personal responsibility of the driver, and he should be held firmly accountable for his acts."

In the May–June issue of *Police*, Dr. Miller recommends:

- A strong campaign to declare drunken driving a serious crime against the public safety.
- Correction of existing laws so that drunken driving is judged on the basis of modern scientific knowledge.
- Adoption of new laws to provide severe penalties for drunken driving.
- Rigid enforcement, staunch public support of the police agencies, and an end to popular mollycoddling of drunks.

Dr. Miller points out that present laws of most States consider an individual "under the influence" only when his blood alcohol test is above 0.15 percent. Recent experiments show driving ability is impaired at about 0.04 percent alcohol in the blood.

In urging the attack on drinking drivers, Dr. Miller states that "evidence has been piling up for years pinning the cause of accidents on the individual. We must get the concept across that driving is a privilege to be prized and cherished, and that when an individual behaves in a way that endangers public safety he should be denied the privilege of driving.

"In about 50 percent of fatal automobile accidents a drinking driver is involved. If we had such clearcut evidence about the cause of cancer, there would be a booming public outcry to put an end to it."