INTERNATIONAL ATOMIC ENERGY AGENCY
UNITED NATIONS EDUCATIONAL, SCIENTIFIC AND CULTURAL ORGANIZATION
INTERNATIONAL CENTRE FOR THEORETICAL PHYSICS
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H4.SMR/638-21

College on Medical Physics:
Imaging and Radiation Protection

31 August - 18 September 1992

The World Health Organization's Programme in Radiation Medicine

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Introduction

The World Health Organization, which was founded on 7 April 1948, is a "specialized agency" within the United Nations system. It is an autonomous international health agency with its own constitution, membership, governing bodies, and budget (WHO, 1988).

WHO works as an international directing and coordinating agency for international health with its ultimate goal (as set out in its constitution), "not merely the absence of disease", but a "state of complete physical, mental, and social well-being". WHO has no executive power over its Member States and is not a supra national Health Ministry. It serves the governments upon their request but is not equipped or empowered to deal with the health problems of individual citizens.

Currently, WHO has 180 M[illegible]er States (as of August 1992) which determine its policy, programme and budget through the World Health Assembly and the Executive B[illegible]ard.

To carry out its work, WHO has a Secretariat, composed of about 4.500 staff members throughout the world. WHO works through a decentralized organizational structure, with a Headquarters in Geneva, and six Regional Offices, Africa, Americas, Eastern Mediterranean, Europe, South-East Asia, and the Western Pacific, plus field offices in many countries.

WHO's biennial budget is approximately 1.5 billion U.S., dollars of which about 1/2 comes from regular contributions from Member States and the other 1/2 is voluntary contributions from governmental and non-governmental donors.

In addition to the use of its regular multi-national staff to carry out its work, WHO depends upon: (1) cooperative efforts with other international organizations; (2) its WHO Collaborating Centres: (3) its panels of expert advisers: and (4) various non-governmental scientific and professional organizations, among which are the International Society of Radiology, and the International Society of Radiographers and Radiological Technicians.

WHO experienced a substantial change in its programme emphasis as a result of the International Conference on Primary Health Care in Alma Ata, USSR, in 1978. That Conference determined that the health status of a large portion of the world was unacceptable and concluded that the primary health care approach was imperative (WHO/UNICEF, 1978). Primary health care is essential health care based on practical, scientifically sound, and socially acceptable methods and technology. It is concerned with the main health problems in the community and provides services accordingly.

Later, in 1981, the delegates to that World Health Assembly unanimously adopted a Global Strategy for Health for All by the Year 2000. This was not a single finite target, but rather a process leading to the progressive improvement of the people's health.

Radiation Medicine Programme

The WHO Radiation Medicine programme deals with several of the health aspects of radiation and is composed of:

(1) Diagnostic imaging, including the use of x rays, nuclear medicine, and ultrasound

(2) Radiotherapy

(3) Protection against radiation used in medical diagnosis and therapy.

Diagnostic Imaging

Peliable data concerning diagnostic imaging services is lacking and the situation varies from country to country, and even between areas in the same country. Nevertheless, the following is generally true:

a) About 80% to 90% of the x-ray machines and the corresponding radiologists and radiographers are located in the few large cities.

b) In most rural and marginal-urban areas the people do not have access to any diagnostic imaging services.

c) Of the x-ray equipment that is installed, at any one time, about 30% to 60% is not in working order.

d) Diagnostic radiologic services in most large-city hospitals are saturated, and patient waiting times for x-ray examinations are long.

e) Many simple x-ray examinations are performed in university or referral-level hospitals because there is no other alternative.

f) Radiologic diagnostic procedures are often conducted without due regard for their proper indication, expected diagnostic yield, and adequate performance; including limitation of dose to the patient to optimal levels.

g) In most countries, medical students have little or no experience with radiological services before beginning their professional careers. A prime need is to institute this training, including appropriate aspects of radiation protection.

h) Quality is variable: very good to excellent in some large hospitals, but, poor in many other hospitals.

i) Cost is increasing, yet, studies have not been conducted to relate it to the control of disease or the recuperation of health.

The situation concerning nuclear medicine services is similar to that of radiodiagnostic services. These services hare highly specialized, with most of the services located in the largest cities (500,000 or more inhabitants), and much of the equipment not in working order. Because of the higher priority for collaboration regarding x-ray services, the approach to nuclear medicine is to promote and support initiatives in the area of quality assurance for the established services.

The method of the WHO Radiation Medicine programme for collaborating with the Member States consists of concentrating, first, on the essential (basic) radiology services. Thus, in the overall context of extending coverage to underserved populations, WHO has collaborated in the development of a Basic

Radiological System (BRS), which is rugged, easily installed and operated, and capable of performing well under adverse conditions of power supply, climate, and hard usage.

Secondly, attention is being given to intermediate level or general purpose radiology for referral hospitals beyond the level of basic radiology. On request, guidance is provided for the selection of appropriate equipment, training of staff, implementation of quality assurance programmes, and for radiological protection.

As specific requests from governments are received, technical cooperation is provided for specialized radiology services in large urban or university hospitals, covering such areas as special radiologic procedures, computer assisted radiology, nuclear medicine, ultrasound, and magnetic resonance imaging studies. Concurrently, activities are carried out where WHO's catalytic role can support technical cooperation among developing countries in such areas as surveys of the radiologic situation, training requirements and standards, quality assurance standards, and effectiveness studies.

Basic Radiology

Although WHO had worked on the problem since the early 1960s, attempts to develop an x-ray machine that was more suitable to the needs of developing countries than the x-ray machines currently available were unsuccessful and by 1970, the consensus of expert opinion was that a more basic x-ray unit was required.

Following the lead of Dr Richard Chamberlain and his co-workers (Dr Philip E.S. Palmer, Dr James Lambeth) of the University of Pennsylvania as eloquently expressed in his article "Basic Radiology, A Worldwide Challenge", efforts were made to start anew from basic principles (Chamberlain, 1970).

Consequently in March 1975, at the Headquarters of the Pan American Health Organization/the WHO Regional Office for the Americas in Washington, D.C., a meeting was organized to address the problem of specifying, on the basis of function, the type of x-ray system that could best serve the radiologic needs of developing countries (a bottom to top approach).

The broad spectrum of requirements for an essential (primary care) radiological system was considered at the Washington meeting, and specifications were prepared. Subsequently, the specifications developed at the Washington meeting were improved and published by WHO in 1982 (WHO, 1985).

Specifications for the X-ray Machine

The current WHO specifications for the BRS x-ray unit, plus accessories, are summarized below:

1. Output of the generator high enough (a) to produce a minimum exposure of 0.5 mR in 1 second or less at a focus-film distance of 140 centimeters, behind a water phantom of 30 centimeters thickness: and (b) to produce 0.5 mR in less than 50 ms at 140 cm behind a water phantom of 12 cm thickness.

2. Rotating anode x-ray tube with a focal spot of less than one millimeter capable of handling 20 kW during 0.1 second.

3. The inherent filtration of the tube must be equivalent to at least 2.5 millimeters of aluminium.

4. The control panel should indicate the states of the electricity supply and the chosen value of kV and mAs, or object thickness; and only for kV values are possible: 120, 90, 70, and 55 kV. The minimum range of mAs values, usable in the entire kV range is 0.8-200 in 25 steps.

5. The design must assure that the tube is always connected to the cassette holder in a rigid and stable way, providing precise centering of the x-ray beam. A fixed focus-film distance of 140 cm must be used.

6. A stationary, focussed lead/aluminum grid with 40 to 50 lines per cm and a ratio of 10:1 must be incorporated.

7. The tube must be provided with an adequate collimator enabling restriction of the x-ray beam to the size of the films used.

8. A movable pointer or other reliable system of centering the beam must be provided.

9. The film sizes should be standardized, and not more than 4 film sizes used. The cassette holder must accept at least the following three formats: 35.5 x 43 cm, 18 x 43 cm, and 24 x 30 cm.

10. The patient support must be rigid, with an x-ray permeable top and able to support a weight of 110 kilograms without appreciable distortion.

11. Strict time/temperature control must be used in the film processing. Darkroom equipment must be provided with the x-ray equipment.

12. A standard range of patient-protection devices must be provided with the x-ray machine.

13. The cassette holder must incorporate a lead shield of a minimum thickness of 0.5 millimeters in the back wall.

14. At least one protective apron and one pair of gloves with minimum thickness equivalent to 0.25 millimeters of lead must be provided.

15. A protective screen, large enough to protect a standing operator, must be an integral part of the control panel. The lead equivalent must be at least 0.5 millimeters, provided that the x-ray beam is never directed at the screen. A leaded-glass window no smaller than 30 cm must be incorporated in the screen.

Succinctly, regarding the hardware: The BRS x-ray apparatus consists of a high quality x-ray generator and x-ray tube, together with a high quality focused grid, and a unique tube-stand; all of which are linked together in a sophisticated manner to produce an optimum (and deceptively simple) x-ray system.

The BRS also includes 3 training manuals which are an integral part of the system:

- Manual of Radiographic Technique (Holm, et al., 1986).

- Manual of Darkroom Technique (Palmer, 1985).

- Manual of Radiographic Interpretation for General Practitioners (Palmer et al, 1985).

- A maintenance and trouble-shooting manual which the manufacturer is supposed to prepare and deliver with each machine.

In 1980 a testing laboratory for prototype BRS x-ray machines was established at the Lund University Clinics (St. Lars Roentgen) under the direction of Dr Thure Holm. This laboratory, which is part of the WHO Collaborating Centre for Basic and Continuing Radiological Education, serves as a focal point for development of the WHO-BRS.

According to procedures established by WHO, x-ray machines produced by various manufacturers are required to undergo thorough testing with respect to the WHO-BRS specifications before being accepted for field trials organized in collaboration with WHO.

Beginning in 1982, clinical field trials of the BRS were organized in various regions of WHO (Africa, Americas, Asia, Europe, and the Middle East).

To date as a result of the various field trials the following has been established:

1. There are very few examinations which cannot be produced by the BRS operator using the WHO Radiographic Technique Manual, which might be needed for patient care in a local hospital. Contrast studies of the alimentary tract are excluded.

2. The quality of the radiographs is very good, even when judged by the standards of the most developed institutions.

3. An abbreviated training period is sufficient to teach radiographic projections, use of the equipment, and the Manual, but is insufficient for the proper instruction of darkroom techniques.

4. With the exception of some early problems involving nickel-cadmium batteries, no significant faults have been discovered with the WHO-BRS type machines.

5. Continuing on-the-job instruction by experienced radiologists and radiographers are an essential part of the system and must be incorporated in any programme utilizing the WHO-BRS.

In a recent assessment made by the Department of Health and Social Security of the U.K. National Health Service, a WHO-BRS type x-ray machine was compared with the installed conventional x-ray equipment in an 800 bed hospital. The radiologists were not given any indication of which films were from the WHO-BRS type unit as they evaluated radiographs of the chest, abdomen, skull (sinuses and facial bones), spine, pelvis, knee, shoulder, and extremities. Over this wide range of examinations, the images produced by the BRS were judged to be excellent in 20 percent of the cases versus only 6 percent for the conventional x-ray equipment (HMSO, 1987).

Other work in progress in diagnostic imaging involves: the rational use of diagnostic imaging procedures effective choices of imaging procedures, development of basic ultrasound imaging, and quality assurance for all imaging modalities.

In 1982 WHO convened a Scientific Group to review the indications for and the limitations of major diagnostic x-ray investigations and to consider methods for improving the use and the availability of diagnostic radiology. The report of this group entitled "A Rational Approach to Radiodiagnostic Investigations" was published in 1983 (WHO, 1983). In 1985 a Study Group was convened to give special attention to the area of paediatric radiology and the report of this group entitled "Rational Use of Diagnostic Imaging in Paediatrics" was published subsequently (WHO, 1987). Because WHO is committed, within the strategies of the process to achieve health for all, to improve the coverage and utilization of diagnostic imaging services; the elimination of clinically unproductive examinations and the careful and rational selection of patients for x-ray examinations are considered to be essential complements to the efforts to provide basic radiology services. Since many medical practitioners must be made aware of the inherent limitations of radiodiagnostic investigations, and since the situation is constantly evolving as new information and techniques become available; dissemination of the type of recommendations made in these two WHO "rational use" reports will be work in progress for some time into the future.

Following the lead of the above-mentioned recommendations, in November 1988, WHO convened a Scientific Group to review the most appropriate sequence for choosing a diagnostic imaging examination and the report of this meeting which is tentatively entitled "Effective Choices for Diagnostic Imaging in Clinical Practice" was published in the WHO Technical Report Series (No. 795) in 1990.

Also in progress is the preparation of a basic manual on ultrasound interpretation for the general practitioner which will provide guidance for the non-specialist physician for the interpretation of the most common investigations. WHO expects to publish this in 1993.

Quality assurance has been an area of concern for WHO for many years and in the nuclear medicine area, international cooperative studies have been organized using specially designed test object on "phantoms". These phantoms, which have been made to simulate human organs such as the brain and the liver, have been sent to nuclear medicine centres in Europe and Latin America in conjunction with studies of imaging quality which have been organized by WHO. In the participating nuclear medicine centres the local nuclear medicine specialist subjects the "phantom" to an imaging study following a common protocol. The specialist then reports his findings concerning simulated lesions or tumours. The reported findings are analyzed by the WHO Collaborating Centres for Nuclear Medicine and the participating laboratory is advised of its diagnostic accuracy along with observations and suggestions for improving techniques.

Currently, WHO, in cooperation with participating nuclear medicine departments, is conducting an international quality assurance study for cardiac imaging, using a special "dynamic phantom" designed by the College of American Pathologists. The first pilot study is being conducted in Europe and, if successful, will be expanded to to other WHO Regions. A new series of studies using a skeletal phatom is expected to begin in cooperation with IAEA in 1993.

Radiotherapy

With regard to radiation therapy, it is estimated that in a well-developed cancer control programme about 50% of the patients will require this treatment. Furthermore, a general consensus of opinion is that, for the treatment to be effective for curative purposes, the heterogeneity in the Planning Target Volume (PTV) should be kept within +7% to -5% of the prescribed dose. Yet, in many countries:

a. The appropriate technology and human resources to provide accurate dosage calculations, treatment planning, and implementation are lacking;

b. A wide range of situations is observed, with very modern and sophisticated equipment in a few advanced centres, and obsolete machines in other hospitals.

The strategy, to extend coverage of radiotherapy services, concentrates on cancers which affect large numbers of people, and which are amenable to treatment with radiation. Treatment needs, in relation to prevailing cancer types are continuously evaluated. Guidance for planning, organizing, and integrating radiation therapy services is provided; as well as guidance for the preparation of staff and the selection of appropriate radiation therapy equipment.

Clinical research on promising treatment methods such as the use of essential brachytherapy in peripheral hospitals for treatment of cancer of the cervix is promoted, along with quality assurance procedures (Mahfouz, 1988).

Radiation Dosimetry

In April 1968 at a meeting on Dosimetric Requirements in Radiotherapy Centres, organized by the International Atomic Energy Agency, in Caracas, Venezuela, in which WHO participated, the establishment of dosimetry laboratories in various regions of the world was urgent recommended.

Soon afterward the first WHO Collaborating Centres for Secondary Standard Radiation Dosimetry were established in Argentina and Roumania, and, other followed in Mexico and Singapore (1970), Iran (1973), Thailand (1973), Nigeria (1975), Brazil (1976) and India (1976).

Later, in collaboration with IAEA, these first WHO Collaborating Centres became the backbone of a worldwide network of Secondary Standard Radiation Dosimetry Laboratories (SSDL). Currently, this network consists of 64 laboratories in 51 countries of which 36 are in developing countries. The resources, abilities and quality are variable. Some of the laboratories are capable of working independently, while other have not progressed beyond the organizational stage and are still highly dependent upon support from the central IAEA laboratory in Vienna. The beginning of order in radiation dosimetry, however, is emerging from the chaos that existed prior to 1968. Typical terms of ref rence for a Secondary Standard Radiation Dosimetry Laboratory are shown below.

Typical Terms of Reference (SSDL)

1. Maintain secondary standard instruments in adequate agreement with the international measurement system, including periodic recalibration in accordance with the procedures of the IAEA/WHO network;

2. Perform calibration of appropriate radiation measurement equipment to an accuracy specified by the IAEA/WHO network, and issue calibration certificates with all necessary information;

3. Participate in measurement comparisons within the IAEA/WHO network, and with other appropriate laboratories;

4. Organize, for its country or region, dose comparison services;

5. Cooperate with the IAEA/WHO network and with other metrological laboratories in exchange of information and improvement of measurement instruments and techniques as necessary;

6. Document and record all procedures and calibrations in a manner specified by the IAEA/WHO network. Preserve all records for a time specified by the network.

7. Keep informed on progress in radiation measurement so as to improve calibration techniques as necessary, and so as to meet more efficiently the needs of the users of radiation;

8. Provide training in techniques of radiation measurement and calibration, and use and maintenance of relevant instrumentation appropriate to the users of radiation served by the SSDL.

On of the most important quality assurance type of activities conducted by the SSDLs is the Postal Dose Intercomparison Study for Radiotherapy Centres. This study utilizes small dosimeters consisting of a thermoluminescent material, lithium fluoride (TLD) which can be sent to participating radiotherapy centres through mail. Following a standard protocol the dosimeters are given a radiation dose which is calculated and administered by the participating radiotherapy centre. The dosimeters are then returned to the SSDL for measurement and evaluation. The resulting information, which consists of a comparison of the calculated dose versus the actual measured dose, is provided to the participating radiotherapy centre along with observations and advice concerning possible sources of any discrepancies and suggestions for improvement.

In some countries with more developed SSDLs, the entire dosimetric intercomparison, e.g., preparation of the TLD, calibration, measurement and evaluation is conducted entirely by the national SSDL. In countries with lesser developed SSDLs, the TLD and the scientific support are provided by IAEA and WHO, with the SSDL collaborating for the national organization and coordination of the dosimetric intercomparison study.

Radiation Protection

Many patients, workers, and members of the public are exposed to unnecessarily high radiation doses due to the use of medical radiologic equipment, which is the major cause of man-made exposure to radiation.

It is imperative to reduce the radiation dose received by the population without sacrificing the benefits; however:

a. Medical and dental students receive little or no instruction concerning radiologic protection.

b. The public has little appreciation of radiologic risks, and hence is not likely to ask the medical and dental professionals about protective measures.

c. Radiation protection services have not been established yet in many countries.

The strategy used by WHO to extend radiation protection services is, first, to concentrate on providing protection in conjunction with extension of diagnostic and therapeutic coverage so that WHO's efforts to provide health benefits will not inadvertently cause harm. The incorporation of radiation protection concepts in the planning of medical diagnostic and therapeutic services is emphasized, and the coordination of quality assurance and radiation protection procedures is promoted.

On request, existing national radiation protection services are provided with technical cooperation in their efforts to extend coverage, and cooperation to establish new radiation protection services is provided for those governments wishing to have them.

An Interagency Committee on Radiation Safety composed of various international organizations with a common interest in the subject of radiation protection was established in 1990. Currently it is composed of the Commission of the European Communities (CEC), the Food and Agriculture Organization of the United Nations (FAO), the International Atomic Energy Agency (IAEA), the International Labour Organisation (ILO), the Nuclear Energy Agency of the Organization for Economic Co-operation and Development (OECD/NEA), the Pan American Organization (PAHO), the United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR) and the World Health Organization (WHO). Observer status has been accorded to several non-governmental organizations such as the International Commission on Radiation Protection (ICRP), the International Commission on Radiological Units and Measurements (ICRU), the International Electrotechnical Commission (IEC), the International Radiation Protection Association (IRPA), and the International Organization for Standardization (ISO). The objective is to coordinate activities in radiation protection and to promote consistency in policies and standards.

Various of the above-mentioned organizations, according to their particular interest and responsibilities are now collaborating in two important activities:

1. the revision of the Basic Safety Standards for Radiation Protection, which as published in 1982 by IAEA;

2. the revision of the Manual on Radiation Protection in Hospitals and General Practice, which was published in five volumes during the period 1974-1980 by WHO.

Conclusion

Where WHO's catalytic role can stimulate cooperation between countries, and in crucial areas where international cooperation is needed, activities may be carried out in such areas as: (a) preparation and dissemination of authoritative information; (b) cooperative quality assurance studies; (c) workshops on specific topics in radiation medicine or protection; (d) seminars on topics that have international implications.

Considering future health needs in the radiological area, diagnostic imaging is one of the most important areas for collaboration. The new imaging modalities such as ultrasound, computed tomography, and magnetic resonance imaging are raising many issues in developing countries. The collaboration of institutions that have special expertise for planning of services and facilities, training, quality assurance, and evaluation of images and results will be invaluable. A related area in which collaboration among centres in developing countries may be more important than with developed countries, involves the rationalization and optimization of the mixture of diagnostic imaging modalities. Within almost any health care system, there is a spectrum of imaging requirements and the associated equipment ranging from the most essential such as the WHO-BRS to the most complex such as computed tomography or magnetic resonance imaging. The issues to be resolved are the clinical decision-making process through which diagnostic imaging examinations are produced and the optimum mixture of diagnostic imaging modalities within a health care system.

Regarding radiotherapy, the shortage of personnel and equipment are major factors that limit its utilization in the developing world. Many areas, especially in Africa, and South-East Asia are deprived of this beneficial treatment modality. Nevertheless, in an increasing number of developing countries, rapid changes in the morbidity and mortality patterns, due to progress made in communicable disease control and the reduction of infant mortality, are bringing chronic diseases such as cancer into prominence as a public health problem.

Consequently, efforts are being made by WHO and IAEA to develop training centres for radiotherapy in various parts of the world; i.e., Egypt, Sri Lanka, Tanzania, Zimbabwe, etc., with the objective of training nationals in their own countries with the equipment and the cancer situation that they will have to deal with in their future activities.

In other parts of the world such as in many countries of Latin America where radiotherapy has been available for many years, the international cooperative efforts will be directed toward improving the delivery of the treatment. All of these efforts must be expanded as the place cancer occupies within the public health priorities becomes increasingly evident to the responsible authorities. The possibilities and the need for international cooperation in this effort are numerous and WHO will rely heavily on the collaboration of the non-governmental organizations, and its relevant collaborating centres.

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