3. Organization and Planning of Imaging and Radiation Therapy Services

3.1 Overview

Conventional basic and specialized diagnostic radiology, interventional radiology, diagnostic ultrasound, diagnostic and therapeutic nuclear medicine, and various forms of radiation therapy today play an essential role in clinical health care processes. The high cost of these services—given the size of the initial investment and the projected operating costs—makes it necessary to plan their development carefully. Due account must be taken of the political and economic characteristics of the health system, the organizational and administrative framework in which the services are provided, and the epidemiological factors that condition the utilization of these services.

In the last decade health care systems in the Region of the Americas have felt the impact of the profound political and economic changes that have occurred on the global level. These changes have had different implications for the organization of health services in each country, but generally speaking there has been a trend toward change in the tradition of state-sponsored public services and a reduction of the preponderant role of governmental agencies in the delivery of health services. For several decades in the Region, especially in Latin America and the Caribbean, direct state action has been the dominant feature of health care. However, in the current context of health reform processes, health services are conceived of from the political and economic standpoints as activities of society which are subject to the conditions of the marketplace. Institutional and financial pluralism in the health system, the quest for efficiency through competitiveness, cost recovery, and other economic values are taking on increasing importance and are gradually becoming the criteria that govern public management of health services.

Although the concept of a single, unified health system is maintained in this new political and institutional framework, that concept is acquiring new dimensions and forms of expression. Private activity is being increasingly recognized as an important component of the health services system, which implies acceptance of a multi-institutional system. The functional elements that link the various institutions have become more important than the structural and

hierarchical considerations that prevailed in the past. Contracting, payment, and remuneration modalities in health care units and schemes of sharing diagnostic, therapeutic, and general logistic support services, among others, have become important means of functional interaction between the entities that make up health systems.

The role and functions of central state agencies are also changing. Ministries of health, in particular, are tending to be less directly involved in the organization and delivery of services, while at the same time they are playing an increasingly important role in managing the process and in coordinating public and private national resources for health care.

In the financial sphere, also, significant changes have occurred. The efforts to curb public spending and downsize governments that characterize current public management have brought about a sizable reduction in direct public funding as a health care financing mechanism. Public health care services, which up to now have predominated in most of the countries of Latin America and the Caribbean, are now being strongly influenced by cost-recovery and rate-setting schemes, the incorporation of semi-private services, and shared payment plans. The end result is a system of mixed public and private financing, in which the extension of government-funded social security to new population groups accounts for an increasing portion of the public component.

All these ongoing changes in the health systems of the Region are creating new interrelationships between the institutions involved in health services delivery. These changes, in turn, affect the traditional modalities by which investment and the operation of health services have been financed and they must necessarily be reflected in the planning and organization of services as important and costly as imaging and radiation therapy.

3.2 Local Development and Organization of Services according to *Levels of Care*

The ***decentralization*** of public administration and recognition of the need to promote and strengthen local actions are other fundamental manifestations of the process of change taking place in the health systems of the countries of the Region (*20*). The strategy of ***local health system*** development and its progressive incorporation in the conceptualization of national health systems is transforming the organizational frameworks for health services and has contributed significantly to the establishment of a new conceptual and technical basis for the planning and programming of health services development (*21*).

In this context, in keeping with the general trend toward stratification of health services according to ***levels of care***, it is necessary to establish the basis for organization and utilization of imaging and radiation therapy services and to specify the scope and possibilities for their contribution to the improvement of the accessibility and quality of health care. To that end, the concept of ***levels of care*** and its application in the organization of radiology services are reviewed in this section.

3.3 Conceptual Elements Relating to the Organization of Health Services according to *Levels of Care*

The notion of ***levels of care*** refers to a stratified approach to the grouping and utilization of resources in order to carry out actions aimed at achieving a specific purpose or meeting a specific need.

In health services, the ***levels of care*** approach has been promoted for several decades as a form of organization that makes it possible to achieve a balance between the quantity, variety, and quality of the resources available for health care, through a process of allocation and distribution of these resources according to needs and capabilities for providing care. The purpose is to develop a harmonious and interrelated set of services that will ensure timely and equitable accessibility to comprehensive health care for an entire population.

In keeping with this orientation, health services must be capable of providing many types and modalities of care, covering a very broad range in variety, intensity, and complexity. For individuals, these services should respond to their specific needs; for the community, they should meet the collective needs of its members.

Application of the concept of ***levels of care*** in health services implies recognition of two components that are quite distinct but must be closely coordinated through planning and programming of service development (*22, 23*). The first of these components is health care needs, i.e., the situations or health problems that affect individuals and groups of people in the community. The second is the responses, or the services—which may be of greater or lesser complexity—that are implemented in order to meet those needs.

Hence, applying the concept of ***levels of care*** means recognizing the increasing complexity of health situations, as well as their relative frequency in a given population, it also means acknowledging the natural relationship that exists between the complexity of a given health situation and the complexity of the methods and resources necessary to address it.

The frequency of the health problems or situations that require attention varies with the sex, age, socioeconomic status, place, time, etc. of the population group in which they occur and the physical and social environment in which the group lives.

For example, diarrheal diseases, gastroenteritis, and acute respiratory infections are more frequent in developing countries and especially in rural areas and the peripheral areas surrounding large urban centers. These health problems can be treated through relatively simple means. However, in these communities there are also pathologies such as brain tumors and cardiovascular conditions that require more complex forms of treatment. In addition, accidents, violence, and injuries are significant causes of morbidity and have begun to displace other pathologies in the general epidemiological profile of these population groups as their living conditions and possibilities for survival improve.

Those situations that affect health in a community determine the demand for services and their relative frequency, and they affect the growing complexity of the resources that need to be mobilized in the health care process. It is thus possible to relate the concept of ***levels of care*** to the geographic location of health care establishments or units, in order systematize the supply of services according to the size, characteristics, and needs (or demands) of different population groups.

In other words, the consideration of these sets of factors makes it possible to relate the notion of ***levels of care*** to the development of a stratified hierarchy of services that complement one another and whose coordinated operation makes it possible to organize and systematize responses to the health care needs of the population.

3.4 Application of the Concept of *Levels of Care* in the Planning and Organization of Radiology Services

The term ***levels of care*** has been used in very different ways in different countries. In some cases, it has referred to the degree of medical specialization required or utilized in the delivery of a given service; in others, it has meant the units or institutional strata of organization and administration of health services. Sometimes the term has been used in relation to the quality of services; in these cases, reference is made to different levels of quality and it is assumed that specialized care, because it is more complex, is of higher or better quality. Quality, however, does not mean sophistication or complexity. Quality has to do with how the service is provided, not with where or with what type of equipment it is provided, nor with who provides the care.

The expression ***levels of care*** actually refers to the technological plane on which problems are solved. It cannot be considered a synonym for the hierarchy of administrative or personnel strata or of the units or establishments that provide services. However, there is a relationship among these various types of levels, inasmuch as, for programming purposes, a given level, and consequently the whole set of levels, will determine the selection and systematization of the most appropriate types of health care units or establishments, depending on the availability of resources for the health system.

Methodologically, the process of establishing ***levels of care*** begins with the identification and ranked classification of health problems and the determination and characterization of the interventions or care functions that are possible with the resources available in the health system in question.

Different criteria may be applied in categorizing or classifying sets of variables: demographic and epidemiological characteristics and the existence of technological, financial, and human resources in the environment in which the delivery of services will take place.

This process of categorization should yield groups of health problems, the first comprising common and simple pathologies that can be treated with basic technology and capabilities, the second made up of other, less frequent and more complex pathologies that require intermediate-level capabilities and technology, and the third composed of infrequent and highly complex pathologies that require specialized care and advanced technology. Although

there may be other systems of categorization, the three-tier system of ***levels of care*** described above is most common.

Once this initial categorization has been accomplished, it is necessary to assign the activities, functions, and responsibilities of the entities that will deliver the services—i.e., the physical facilities in which care will be provided. Through this assignation of activities, the concept of ***levels of care*** is operationalized. It is in this phase that the types of personnel and equipment required are determined and the other elements necessary for carrying out the assigned actions are identified. In other words, it is in this phase that the technological characteristics of the establishments in which care will be provided are defined.

The foregoing implies that the services to be provided by the various ***levels of care*** are not the same in all situations, nor even within a single country. Moreover, not all the establishments in which services are provided or the units they comprise have the same characteristics, even when they fall into the same category.

With these characteristics, it is evident that the functional interpretation of the ***levels of care*** approach provides a solid conceptual basis for planning and organizing the various components of radiology services as essential elements in the strategy of ***local health system*** development.

3.5 Planning of Radiology Services according to *Levels of Care*

This section looks at three interrelated components that form the basis for interpretation of the concept of ***levels of care*** in the specific area of radiology services.

- The general approach, i.e., the fundamental conceptual elements.
- The analysis of needs, which in this case, given the characteristics of radiology services, takes into account primarily data on utilization and utilization trends.
- Resources, or the availability of technological solutions in the different areas of radiology which can be applied and combined, depending on the characteristics of the health services system in question.

3.5.1 General Approach

Decisions regarding ***levels of care*** are based, first, on the identification and analysis of health problems and, second, on the possibilities for combining available resources to achieve an adequate supply of services.

The identification of health problems is not an easy task, and there are no exact indicators for all manifestations of these problems. The events that experts interpret as problems are frequently not viewed by the population as such. The reverse may also occur. In the process of establishing what the real needs are, it is essential to achieve the greatest possible congruence between these interpretations through broad participation by the various groups that make up the population.

Once the health problems have been identified, the next step is to determine their frequency, magnitude, and severity. In addition, it is necessary to identify the geographic distribution of these problems, the population affected by them, and their evolution and trends. The basic tools for carrying out this analysis are epidemiology and its various techniques, whose appropriate utilization will make it possible to rationalize the definition of programming objectives and establish priorities for resource allocation.

Taking into account the particular characteristics of each country or region, the area served by a ***local health system*** is the natural focus for these epidemiological analyses. Knowledge of the population served by a ***local health system*** will allow greater specificity in the diagnosis of diseases and better selection of interventions in order to ensure accessibility and coverage.

The second essential component in the technological determination of ***levels of care*** is resource availability. In this regard, the variety of situations observed is also very broad. The primary factors that influence these situations are the degree of development of the countries; the urban-rural distribution of the population; the characteristics of the health system, in particular its institutional and financial make-up (i.e., the public-private mix); and the availability of health personnel. This last factor is particularly important in local areas, where the availability and participation of the various kinds of health personnel, especially physicians, nurses, and dentists, is a critical consideration in the determination of the set of services to be provided at the first ***level of care***.

It is widely recognized today that the population's first contact with health services should not necessarily be through the physician. Other health workers—physician's assistants, paramedical personnel, volunteers, etc.—can

provide the initial attention. In fact, this is what occurs in day-to-day reality. In rural areas of some countries, there may be no intermediate step between care by a non-physician health worker and hospital care. However, according to the functional interpretation of the concept of ***levels of care*** used in this publication, the initial contacts and actions carried out by auxiliary health personnel and community workers should be considered extensions of professional medical activity.

In other words, the set of services available at the first ***level of care*** should include diagnostic capabilities and treatment by medical professionals. This is an important consideration in relation to the establishment of radiology services at the first ***level of care***.

Professional medical activity at the first level may be carried out by general practitioners or by various combinations of specialists, in particular obstetricians, internists, and pediatricians. In some countries family or community medicine schemes or other similar schemes have been established for this purpose. The demand for and utilization of radiology services will vary depending on the types of medical professionals practicing at the first ***level of care***.

In general, when health service use patterns are analyzed in the planning process, it is essential to bear in mind that both the services provided to protect the health of individuals and social groups and the use that the population makes of these services will depend to a large extent on the interaction of health workers with the population.

This points up two important needs. First, it is imperative to maintain controls in order to avoid inappropriate utilization of the services, which occurs very frequently. Second, it is necessary to facilitate the population's participation in those areas in which it is appropriate.

Although the need for community participation is recognized, it is not always easy to achieve, especially in some types of services, as is the case with imaging and radiation therapy. Radiology services are highly "technical" and are therefore generally beyond the population's grasp. Health education and innovation are required to make information in this area accessible and thus enable users of the services to participate, especially in the development of appropriate service use patterns. It is also necessary to define the objectives of community participation and to determine who should participate and how they should participate in order to achieve those objectives. The role of experts should be to provide information and support health education programs.

3.5.1.1 Analysis of Needs and Demand

Imaging and radiation therapy services are support elements in the clinical process. The degree to which they are used depends to a large extent on the decisions made in this process. Through these decisions the diagnostic and therapeutic resources available in the health system are mobilized. Hence, as in any process of health service planning, the first step in planning imaging and radiation therapy services must be analysis of morbidity and mortality, accompanied by a review of the patterns of utilization of the various radiological procedures, which, in practice, express the demand for those activities. The morbidity and mortality analysis, and the specific national and local manifestations of the corresponding indicators, will make it possible to establish needs and arrive at an overall decision regarding the types of services that will be required in each situation.

It is not within the scope of this publication to delve into the various qualitative and quantitative methods that are available for this purpose. It should be noted, however, that morbidity data alone are not sufficient to define the course to be taken in developing certain services.

In the case of radiology services, as with other diagnostic and therapeutic support services, measures or indicators of demand are a more objective basis for planning. That demand is established through analysis of utilization patterns and trends, which makes it possible to project future requirements for these services and thus establish a basis for making decisions about the corresponding health care centers. In this regard it should be pointed out that the annual frequency of radiological procedures per person varies considerably from country to country.

As is shown in Tables 2.1 (*6*) and 2.2 (*5*), there are differences of up to 30 times per year in individuals' use of these services in developing countries, compared with the industrialized countries.

It is generally accepted (*5*) that chest x-rays are the most frequent radiological exams in all the countries. In category-I countries, between 60% and 70% of the radiological studies carried out are simple chest x-rays. Another 10% might be x-rays of limbs and other parts of the skeleton. Examinations of the abdomen and digestive tract, including cholecystographies and urographies, might also account for 10% of the total. Hence, only about 10% of all the radiological examinations performed require a greater degree of specialization.

The proportions of chest and limb x-rays in the developing countries, tends to be higher, and the proportion of specialized studies is therefore quite lower —usually under 10%.

According to the UNSCEAR report for 1993 (5), the diagnostic imaging service use trends indicate:

- An increase in the frequency of all the types of radiological examinations, especially in the developing countries.

- In particular, there has been a rising trend in the number of chest x-rays, which have increased from 10 to 100 and from 20 to 50 per 1,000 population in the least developed countries (those in categories III and IV, respectively). Fewer chest x-rays tend to be performed in the most developed countries (those in categories I and II), apparently due to the decrease in mass screening x-ray studies.

- In countries with an intermediate degree of development, the greatest increases have been in the use of computed tomography and x-rays of the skull and the abdomen.

- Mammography has shown a sharp rising trend as its advantages as the only method for early diagnosis of breast cancer have become recognized.

- The numbers of x-rays of limbs, the backbone, and the digestive tract, as well as cholecystograms and urograms, have tended to remain stable in recent periods of 2 to 5 years.

- However, there has been an increase in the use of ultrasound for abdominal diagnosis, which has led to more rational utilization of simple imaging studies.

- In the countries in categories II to IV, the proportion of children is greater than in those in category I. This is reflected in a larger proportion of x-rays studies performed on children in the former countries.

- Among children, the most frequent radiological examinations performed are x-rays of the thorax, limbs, skull, pelvis, hip, and abdomen, and urography.

- With regard to the sex of the patients, there are no significant differences in utilization trends, although a greater number of women undergo cholecystography.

As for nuclear medicine, the information from UNSCEAR indicates that most examinations of this type are performed on adult patients. On the average, the population examined with nuclear medicine techniques is older than the general population and also older than those on whom ***x-ray*** examinations are performed.

The UNSCEAR report notes that the number of nuclear medicine examinations increased in the industrialized countries during the 1970s and remained relatively constant during the 1980s. In the developing countries, the frequency of nuclear medicine examinations is expected to increase.

An important trend in this area is the introduction of complex biological agents such as monoclonal antibodies tagged with ***radionuclides***, which have become not only a very useful diagnostic tool for locating tumors and detecting metastasis, but also a therapeutic tool for localized treatment of certain tumors. Another noteworthy trend is the increasingly widespread use of ***SPECT*** and ***PET*** units. One of the most recent trends is interventional radiology, whose use is gradually supplanting surgical procedures (*24*) and thus reducing days of hospitalization. In the area of radiation therapy, the highest degree of technological complexity is seen in intraoperatory radiation therapy facilities and in the proliferation of high-***dose***-rate remote afterloading brachytherapy devices.

These developments and their increased use will undoubtedly lead to higher per capita rates of radiation use.

Although use and trend analyses must take account of differences in national and local situations, these overall appraisals would seem to indicate that the most frequently used installations will be those that perform simple chest and limb x-rays.

Such installations should therefore be part of the set of services available at the primary ***level of care***.

There will also be need for a second set of services to make it possible to carry out more complex radiological studies, such those of the digestive tract, and radiation therapy treatments with low-megavoltage equipment, such as cobalt-60 units, which will be used somewhat less frequently. A third, more

specialized set of services will be used even less frequently. The respective services should be placed in secondary- and tertiary-level services.

3.5.1.2 Analysis of Available Resources

As was noted above, the general availability of resources for health care varies with the countries' degree of development and the organizational and financial characteristics of their health services systems. The availability of resources also varies depending on whether the environment is urban or rural.

With regard to radiology services, the necessary resources include physical facilities, equipment, personnel, organization, management, and technology. The latter comprises the techniques and procedures used for diagnostic and therapeutic purposes. In the determination of ***levels of care***, these technological resources and their possible combinations constitute one of the central elements in the stratified organization of services. Consequently, the resources need to be identified carefully and consideration must be given to the specific types of resources needed for imaging, radiation therapy, and nuclear medicine, as appropriate.

3.5.2 Imaging

In terms of imaging, the available technological resources can be grouped as follows:

- Conventional radiography, which permits studies of anatomical structures; specialized radiography, which is distinguished from conventional radiography mainly by the use of various types of contrast media. One form of specialized radiography that does not use contrast media is mammography, which is used to diagnose breast cancer and detect preclinical breast cancer in asymptomatic women.

- Fluoroscopy, now with image intensification, which permits functional studies. Fluoroscopy is also used in interventional radiology as a guide before, during, or after surgical procedures or in conjunction with other examinations or treatments. For example, fluoroscopy may be used in procedures involving the insertion of catheters or instruments for drainage, removal of calculi, occlusion, dilatation, or rechanneling of blood vessels; or infusion of drugs

- Recording of fluoroscopic images, using radiographic film in a spot film device, on 16 mm film using a motion picture camera, or by electronic means. Fluoroscopic images can also be manipulated digitally—as in the case of digital substraction angiography (DSA)—or produced directly by digital means. For example, most of the equipment used in interventional radiology utilizes digital fluoroscopy (*24*).

- Computed tomography, in which multiple ***x-ray*** beams transmitted from several angles toward the patient are captured by radiation detectors and processed by a computer in order to obtain tomographic images.

- Diagnostic ultrasound, which uses ultrasonic mechanical waves to visualize anatomical structures. When the Doppler effect is also utilized, it is possible to perform functional studies, that is, studies of the physiology of organisms and their systems.

- Magnetic resonance imaging, which produces images by utilizing the ability of certain atomic nuclei to selectively absorb electromagnetic radiofrequency energy when they are placed in a powerful magnetic field.

- Nuclear medicine, in which radioactive substances are administered to the patient and their spatial location and temporary concentration are detected through the use of detectors and equipment capable of producing morphological images on one or several planes and curves of metabolic function.

In this schematic review of technological resources for imaging, special emphasis should be given to the Basic Radiological System developed by PAHO/WHO—now called WHIS-RAD (*19*).

3.5.2.1 The Basic Radiological System (BRS)

Because approximately two-thirds of the world population lacked access to diagnostic imaging services, during the period 1975-1985, PAHO and WHO focused their efforts on the development of the Basic Radiological System (BRS) (*15*). The BRS consists of a simple but rugged radiography unit that incorporates design elements that make it capable of producing high-quality ***x-rays*** with little maintenance.

Although WHO had been working on this problem from the early 1960s, it had been unsuccessful in its attempts to develop an ***x-ray*** machine that was more suited to the needs of developing countries than the ***x-ray*** machines that were available at the time. By 1970 the consensus of the experts was that a more basic ***x-ray*** unit was needed.

The broad spectrum of requirements for a basic radiological system were considered, and after a meeting held at PAHO in 1975 the specifications for a simple high-quality ***x-ray*** machine were developed (*15*).

In regard to the equipment, the BRS ***x-ray*** unit consists of a high-quality ***x-ray generator*** and tube, together with a focused grid and a unique tube stand, all of which are linked together in a sophisticated manner to produce an optimum but simple ***x-ray*** system.

Three training manuals are an integral part of the system, and WHO produced official versions of them in Arabic, English, French, and Spanish. The set of three manuals includes: the *Manual on Radiographic Interpretation for General Practitioners* (*16*); the *Manual on Radiographic Technique* (*17*), and the *Manual on Dark-Room Techniques* (*18*).

In addition, the manufacturer is expected to prepare and deliver with every machine a manual on maintenance and detection of failures.

In 1980 a laboratory was established to test BRS prototype ***x-ray*** machines at the St. Lars Roentgen Clinic of the University of Lund in Sweden. This laboratory, which is part of the WHO Collaborating Center for General and Radiological Education located within the Department of Radiology of the University of Lund, serves as focal point for the development of the WHO-BRS.

The essential elements of the WHO diagnostic imaging system were clarified during a WHO consultation meeting that took place at the University of Lund, Sweden, in June 1993. Among those participating in the meeting were radiologists, radiological technologists, radiological physicists and engineers, and representatives of the industry (*19*).

The WHO diagnostic imaging system, once it is completely developed, will consist of units, accessories, and training manuals for the diagnostic imaging modalities of radiography and ultrasound, as well as a system for the management of images produced through computerized tomography, magnetic resonance imaging, and nuclear medicine.

The radiographic unit of the WHO diagnostic imaging system (known by the acronym WHIS-RAD) is an updated version of the WHO-BRS unit. Changes were made at the suggestion of radiologists and technologists responsible for supervising examinations performed with the WHO-BRS. As a result of a few simple modifications, the new WHIS-RAD has become even more versatile and more appropriate for use in the industrialized world as well as in the developing countries.

The WHIS-RAD produces the same high-quality results that made the WHO-BRS the unit of first choice in many situations. Building on the success of the WHO-BRS, the developers of the WHIS-RAD introduced modifications that would make it possible to use the unit in a broader range of situations in which a fully trained radiological technologist was available to supervise its operation.

The specifications for the WHIS-RAD equipment appear in the Appendix I-A (*19*). This appendix also contains a list of specifications for general-purpose diagnostic ultrasound equipment (I-B) (*7*). The WHO publication *Manual of Diagnostic Ultrasound* (*25*) is currently being translated into Spanish and French.

3.5.3 Radiation Therapy

Radiation therapy, together with surgery and chemotherapy, is one of the pillars of cancer treatment. It is estimated that radiation therapy is used in the management of approximately 40% to 80% of all cancer patients, either as the sole method of treatment or in conjunction with surgery, chemotherapy, and/or hyperthermia.

The main technological resources available in this field are:

- Teletherapy, in which the irradiation ***source*** is external. Superficial and orthovoltage ***x-ray*** units (the latter are now practically nonexistent), ***radionuclide*** units such as cobalt-60 units, and linear ***accelerators*** are the main types of equipment used.

- Brachytherapy, which utilizes ***sealed*** radioactive ***sources*** in intracavitary, interstitial, or superficial implants.

- Therapeutic nuclear medicine, in which the patient is given radioactive substances that irradiate the organ which takes them up. The

radionuclides most commonly used are iodine-131 for carcinoma of the thyroid, strontium-89 for treatment of bone metastases, and several monoclonal antibodies tagged with various ***isotopes*** for treatment of colon cancer and other malignancies.

The use of ***ionizing radiation*** for therapeutic purposes is a complex process, which requires the collaboration and interaction of personnel trained in various disciplines A critical step in this process is the initial evaluation of the patient and his/her tumor. These circumstances make it essential for these services to be located in complex-care units of the health system.