8. Basic Principles and Practical Aspects of Radiation Protection

8.1 Overview

Ionizing radiation poses a physical ***risk*** to people, who may be exposed by natural and artificial means. The interaction of radiation with matter produces ***ionization*** phenomena capable of modifying the chemical behavior of molecules. If this occurs in live cells, biological effects of varying degrees of severity can result.

People who work with ***sources*** of ***ionizing radiation***, some ***members of the public***, and patients who undergo radiological procedures are exposed to the ***risks*** of ***ionizing radiation***. It is not possible to totally eliminate these ***risks***, but it is feasible to control them and keep them within acceptable ***limits*** through application of the principles of radiation protection.

Radiology services should be designed and operated on the basis of these principles in order to adequately protect ***workers***, patients, and the general public. In order to achieve systematic application of the principles, it is necessary for the countries to adopt radiation protection standards and establish a regulatory agency to enforce them. It is also important to ensure adequate training of the human resources involved in radiology services (see Appendix III).

8.2 Characteristics and Interactions of *Ionizing Radiation*

Forms of ***ionizing radiation*** include ***x rays***, ***radiation*** produced by radioactive substances and nuclear reactions, radiation generated in particle ***accelerators***, and radiation of cosmic origin (***cosmic rays***). The various types of ***ionizing radiation*** differ in mass, electric charge, and the energy of their particles. These properties determine how radiation will behave when it interacts with matter.

Radiation composed of electrically charged particles, such as ***alpha*** and ***beta particles***, are capable of directly ionizing the atoms of a material with which they interact. This type of radiation is called "direct ***ionizing radiation***". ***Gamma rays*** and ***neutrons***, which are not electrically charged, emit charged particles when they interact with matter. It is these particles which ionize the atoms of the material. This type of radiation is called "indirect ***ionizing radiation.***"

When a radiation beam interacts with matter, it releases some of its energy in each ***ionization*** process, and the radiation thus diminishes in intensity along the beam's path. This phenomenon is exploited in the design of ***shielding*** materials.

8.3 Microscopic Distribution of Ions

The microdistribution of ions generated by ***ionizing radiation*** can be highly diverse and depends on the mean quantity of energy that its particles give off per unit of distance traveled (linear energy transfer, LET). Some particles, such as ***alpha particles*** and ***protons***, concentrate the ions that they generate in small volumes, whereas ***electrons*** scatter the ions in much greater volumes The degree of ion concentration in the matter influences the biological effects that may be produced when biological material is irradiated.

8.4 Types of Radiation *Exposure*

People can be exposed to ***ionizing radiation*** produced by external ***sources*** such as ***x-ray*** machines or cobalt therapy units. This type of ***exposure*** is known as external irradiation.

A person's tissues may be also be exposed as a consequence of the intake of radioactive material into the body through inhalation, ingestion, or wounds. ***Radioisotopes*** are absorbed selectively by certain tissues according to the metabolism associated with the chemical characteristics of the molecules of which they are a part. This is known as internal irradiation or ***contamination***.

This distinction between types of ***exposure*** is important for determining which radiation protection techniques will be most appropriate in each case.

8.5 Quantities and Units Used in Radiation Protection

In radiation protection, appropriate quantities and units are defined to assess radiation ***exposure*** and correlate it with biological effects. The quantities and units most frequently utilized in radiation protection are defined in the glossary.

The fundamental dosimetric quantity is called the ***absorbed dose***, which is defined as the energy that an irradiated material absorbs per unit of mass. In ***practice***, for radiation protection purposes, in procedures involving the irradiation of people it is more useful to know the value of the organ or tissue ***dose***, which is the mean energy that the organ or tissue receives per mass unit. In the scientific literature, the letter D is used to denote ***absorbed dose***.

The unit of ***absorbed dose*** is the joule per kilogram ($J \cdot kg^{-1}$), termed the gray (Gy).

Because the ***absorbed dose*** is a strictly physical quantity, it is not always possible to establish an appropriate correlation between it and the biological effects of radiation. At the same ***dose*** level, different types of radiation can produce different effects, owing to the diverse ways in which the ions are distributed microscopically. In order to take account of this phenomenon, the ***absorbed dose*** is weighted by a factor that depends on the type of radiation (see Appendix VIII-A), which yields a value called the ***equivalent dose***. The unit of ***equivalent dose*** is also $J \cdot kg^{-1}$, but in this case it is termed the sievert (Sv). It is identified by the letter H. Different tissues and organs have differing degrees of radiosensitivity, or susceptibility to biological effects as a result of radiation, which can be taken into account by using a specific ***tissue weighting factor*** (see Appendix VIII-A) The quantity that results from the summation of the ***equivalent doses*** to all tissues and organs, each multiplied by the appropriate tissue weighting factor, is called the ***effective dose***. It is also expressed in sievert (Sv) and is represented by the letter E.

These units can have multiples and submultiples, such as kilo (10^3), mega (10^6), milli (10^{-3}), micro (10^{-6}), etc.

8.6 Natural and Artificial *Sources* of Radiation

People are exposed to ***ionizing radiation*** from both natural and artificial ***sources***. Natural ***exposure*** comes from radioactive substances existing in the earth's cortex and in radiation from cosmic space. Artificial ***exposure*** results from the use of radiation-emitting equipment and radioactive materials for medical, industrial, research, and energy-generation purposes.

Every inhabitant of the planet receives an average ***dose*** of 2.4 mSv per year. The most important ***source*** of natural ***exposure*** is ***Radon***-222 and its decay products. ***Radon*** is a gas found abundantly in nature, especially in construction materials. Potassium-40, an element found in the human body, also contributes to natural ***exposure***.

The most important ***source*** of artificial ***exposure*** is the use of radiation in the medical field. More than 80% of the artificial radiation ***dose*** to people comes from medical radiodiagnostic procedures (*5*).

Appendix VIII-B lists the annual average ***doses*** of radiation from various ***sources***.

The concept of radiation ***source*** includes radioactive substances and equipment that contains radioactive substances or produces radiation, including consumer products, ***sealed sources***, and ***unsealed sources***.

8.7 Biological Effects of *Ionizing Radiation*

The interaction of ***ionizing radiation*** with a biological medium can give rise to biological effects. The ***ionization*** of atoms modifies the chemical behavior of the molecules of which they are a part, inducing reactions that cause morphological or functional changes in cells.

The molecules of deoxyribonucleic acid (DNA) are the most vulnerable targets within cells. One significant effect of ***exposure*** to ***ionizing radiation*** can be the inability of the cell to reproduce. ***Ionizing radiation*** can also produce changes in the genetic information of the cell without affecting its reproductive capability.

The biological ***effects*** of radiation are classified as ***deterministic*** and ***stochastic***.

8.7.1 *Deterministic Effects*

Deterministic effects are produced when a sufficiently large quantity of cells die or lose their reproductive capability due to radiation. The severity of the effect increases as the ***dose*** received increases over a certain threshold level, which varies depending on the tissue or organ in question. (See Appendix VIII-C.)

The symptoms that are manifested when the entire body is exposed to acute radiation, that is, radiation of brief duration, constitute the acute radiation syndrome. If the whole body ***dose*** is on the order of 3.5 Gy, there is a 50% probability of death, which may occur 30-60 days after the time of irradiation.

8.7.2 *Stochastic Effects*

When ***ionizing radiation*** produces changes in the genetic information of the DNA molecules in cells without affecting their reproductive capability, ***exposure*** to radiation can induce cancer in the long term. This type of effect is ***stochastic***, which means that it can only be predicted statistically. There is no threshold ***dose***. The probability that such effects will occur is proportional to the ***dose*** received.

The ***risk*** of death from cancer is estimated at 5% per Sv for the public and 4% per Sv for those exposed occupationally (since the latter group does not include young people under 18 years of age) (*67*).

When irradiation occurs during gestation, the possibility of mental retardation is the most important effect. The ***risk*** is highest during the period between weeks 8 and 16 of pregnancy.

8.8 Radiation Protection Concepts

The International Commission on Radiation Protection (ICRP) issued its most recent basic recommendations on radiation protection in 1991, in ICRP Publication No. 60 (*67*). These recommendations led to the joint publication of the *International Basic Safety Standards for Protection Against Ionizing Radiation and for the Safety of Radiation Sources (BSS)* by the Food and Agriculture Organization of the United Nations (FAO), the IAEA, the International Labor Organization (ILO), the Nuclear Energy Agency of the

Organization for Economic Cooperation and Development (NEA/OECD), PAHO and WHO (*26*). These documents establish the basic principles of radiation protection and provide practical guidance for their implementation. The main principles are summarized below.

Sources of radiation are utilized in various ***practices*** that result in the ***exposure*** of people. Depending on the group of people involved, radiation ***exposure*** is classified as ***occupational exposure***, in the case of ***workers***; ***public exposure***, in the case of ***exposures*** incurred by ***members of the public***, and ***medical exposure***, in the case of patients, support personnel who are not occupationally exposed, and volunteers in research programs.

The decision to accept the initiation of a ***practice*** involving ***sources*** of radiation makes it necessary to analyze the ***risks*** that the ***practice*** may entail, both during the execution of planned operations ***(normal exposures)*** and in the event of radiological ***accidents*** that might result in higher-than-expected ***doses (potential exposures)***.

Sometimes ***exposures*** occur and it is not possible to act on their causes, as in the case of ***accidents*** or natural radiation in certain circumstances. In such cases, whenever feasible, appropriate measures should be taken to prevent unacceptably high radiation ***doses***. Such situations are called situations that require ***intervention***.

The objective of radiation protection is to prevent ***sources*** of radiation from causing ***deterministic effects*** on people and to reduce the likelihood of ***stochastic effects*** as much as possible taking into account economic and social considerations. There are three basic principles that sum up the philosophy of radiation protection:

8.8.1 Justification

No ***practice*** involving ***ionizing radiation*** should be accepted unless there is evidence that it will produce, for individuals or society, benefits that outweigh the possible ***detriment*** it may cause. The application of this principle helps to prevent the utilization of radiation ***sources*** for nonessential purposes.

8.8.2 *Dose* Limitation

In order to reduce the magnitude of the ***risks*** associated with a justified ***practice***, ***limits*** on individual ***doses*** are established to prevent the occurrence of ***deterministic effects*** and minimize the likelihood of ***stochastic effects***. Monitoring of the application of these ***limits*** should take account of ***doses*** generated by external ***sources*** and those produced by the intake of ***radionuclides*** into the body. Appendix VIII-D lists the ***dose limits*** applicable to ***workers*** and to ***members of the public***.

8.8.3 Optimization of Protection

Dose limits do not constitute ***risk*** thresholds; they represent the maximum tolerable levels of ***risk***. In most applications of radiation ***sources***, it is feasible to adopt measures to ensure that the radiation ***doses*** people will receive are significantly lower than ***dose limits***. Optimization is the process in which an analysis is undertaken and decisions are made regarding the magnitude of resources that can reasonably be devoted to radiation protection in order to minimize radiation ***doses*** to the extent possible, taking into account economic and social factors.

8.8.4 *Potential Exposures*

Potential exposures are those that may result from possible radiological ***accidents***. It is not possible to rule out their occurrence from accidental events. In an ***accident*** situation, control over the ***source*** or people is lost, and radiation ***doses*** may be considerably larger than planned for the normal operation of a facility.

Past experience with ***accidents*** and knowledge of the characteristics of radiology facilities makes it possible to anticipate the various ***accidents*** that could occur and to design safety systems to prevent sequences of events that might lead to ***accident*** situations.

The criterion to be applied in this regard is the following: the more serious the potential consequences of an ***accident*** are (i.e., the higher the ***dose*** that it could entail), the lower the probability of its occurrence should be.

8.8.5 Situations Requiring *Intervention*

Typical situations that may require ***intervention*** include:

- Emergency ***exposure*** situations requiring protective action to reduce or avert temporary ***exposures***, such as radiological ***accidents***.
- Chronic ***exposure*** situations requiring remedial action to reduce or avert chronic ***exposure***, such as certain cases of natural ***exposure***.

The criteria for justification and optimization are also applicable to ***intervention*** actions. Justification in this case means that the ***intervention*** should be undertaken only if its benefits (avoidance of radiation ***doses***) are greater than the ***detriment*** it might cause. Optimization, in the case of ***interventions***, is the analysis carried out to decide on the most appropriate means of ***intervention*** (and that which will yield the greatest net benefit).

The ***dose limits*** foreseen for planned ***practices*** are not applicable in ***intervention*** situations. However, application of the concept of ***intervention levels*** provides a useful guide for rapidly deciding on the most appropriate course of action. These levels indicate the type of action needed in ***accident*** situations, depending on the severity and characteristics of the situation. The *BSS* establish guidelines for these ***levels*** (*26*).

8.8.6 Special Considerations Relating to *Medical Exposures*

The concepts discussed above are applicable to both ***occupational*** and ***public exposures***. In the case of ***medical exposures***, there are some special considerations in relation to the three aforementioned principles.

It is not possible to establish ***dose limits*** for the ***exposure*** of patients, since in each case the balance between ***risk*** and benefit will be different. In the final analysis it is the responsibility of the physician to determine whether or not a radiological procedure is justified, and it is the responsibility of the respective specialists (radiological technologists, medical physicists, etc.) to determine the conditions under which the procedure should be performed.

Diagnostic procedures should be carried out using all available means to reduce patient ***exposure*** without affecting the necessary image quality; this what is meant by optimization. The *BSS* (*26*) recommend the adoption of ***guidance levels*** for the various ***practices***.

In radiation therapy, patients should be irradiated with a high degree of accuracy, both in the value of the ***dose*** and in its location. Every effort should be made to minimize ***exposure*** of healthy tissues. This is what is meant by optimization, and this implies maintaining strict ***quality control*** procedures.

The prevention of ***potential exposures*** is particularly important in the case of radiation ***sources*** used for medical purposes. Worthy of mention in this regard are several ***accidents*** that have occurred, including one with a linear ***accelerator*** in Zaragoza, Spain, which over-irradiated 27 patients (*58*), resulting in several deaths among them; one with a caesium-137 teletherapy ***source*** in Goiania, Brazil, which resulted in the death of four members of the general public (*68*), and one with a cobalt-60 teletherapy ***source*** in Ciudad Juarez, Mexico, which led to the overexposure of numerous ***members of the public*** and caused significant material damages (*69*).

8.9 Implementation of Radiation Protection and Safety Measures

The only way to control the ***risks*** associated with ***ionizing radiation*** is to restrict and monitor the radiation ***doses*** that individuals receive under normal conditions and to adopt safety measures to reduce the probability of ***accidents***.

Reduction of radiation ***doses*** from external ***sources*** can be achieved by increasing the distance from ***sources***, interposing ***shielding***, or diminishing ***exposure*** time. In the case of internal irradiation, it is only possible to reduce ***doses*** by controlling people's intake of radioactive materials. For each ***radioisotope*** it is possible to calculate the annual maximum intake (***annual limit on intake***) that will yield a ***dose*** over a period of time (***committed dose***) that does not exceed the ***dose limit***. The *BSS* (*26*) gives the values of the ***committed effective doses*** per unit of ***activity*** for every ***radioisotope***.

8.9.1 Distance

Generally speaking—assuming that the ***source*** is a point ***source***—the ***dose*** depends inversely on the square of the distance. Doubling the distance reduces the ***dose*** to one fourth. Increasing the distance tenfold decreases the ***dose*** one hundredfold.

Example: An *x-ray* machine is placed in the center of a room. If the distance of the equipment to one of the walls is 1 meter and the ***dose*** rate at this point is 1 mSv/hr; by increasing the distance to 2 meters, the ***dose*** rate would diminish approximately to 0.25 mSv/hr.

8.9.2 *Shielding*

The interposition of material between radiation ***sources*** and people is an important means of reducing the ***dose*** of radiation. The intensity of the radiation beam is attenuated exponentially.

The ***half-value layer*** is defined as the thickness of the ***shielding*** material which reduces the beam intensity by one half. The ***half-value layer*** is a characteristic of each type of material and of the radiation energy utilized.

The ***shielding*** material most commonly used in diagnostic radiology is lead and in radiation therapy, concrete.

Example of equivalent ***shielding*** *(70)*:

Material	***X Rays*** **(70 kVp)**	**Co-60**
Concrete	8.4 mm	62 mm
Lead	0.17 mm	12 mm

8.9.3 Time

There is a linear correlation between ***dose*** and ***exposure*** time. ***Exposure*** time refers to the length of time during which a person is in proximity to ***sources*** when they are being used for irradiation; it does not bear any relation to the length of the work day.

8.9.4 Control of *Contamination*

The use of ***unsealed sources*** creates the potential for radioactive material to spread to work surfaces and materials, floors, and walls, thereby contaminating them and the air in the surrounding area. Control of such ***contamination*** is achieved by keeping work surfaces and materials clean and using a forced ventilation system, equipped with filters, in environments in which ***unsealed sources*** are used.

8.9.5 Safety Systems

Accident prevention should be envisaged in the planning and operation of all radiology services.

The aim in designing safety systems is to reduce the likelihood of ***accidents*** to acceptable levels. To this end, safety systems should be redundant and independent.

The experience gained from past ***radiological accidents*** has shown that the most important factor is the human factor. The influence of the human factor should be minimized, since it is one of the least reliable elements in routine circumstances. For those functions in which ***intervention*** is necessary, the individuals carrying out the ***intervention*** must have adequate training and be in an appropriate psychophysical state. ***Intervention*** procedures should be described in codes of ***practice***.

8.10 Application of Radiation Protection in Radiology Services

In radiology services, as in any other installation, both ***occupational exposure*** and ***public exposure*** should be taken into account. In addition, ***medical exposure*** must be considered.

Outlined below are the most important recommendations that should be borne in mind in the design and operation of radiology services. For each ***level of care***, there may be specific additional requirements, depending on the complexity of the services provided.

In order to provide adequate radiation protection, every radiology service should be appropriately planned and installed, the equipment should comply with certain essential design requirements, and maintenance and ***quality control*** should be ensured. The staff should possess appropriate knowledge and training in their particular specialties and in radiation protection.

8.10.1 General Design Requirements (*36, 68*)

The structural design of each radiology service should be in accord with its functional characteristics and the need for interrelationship with other medical care services. ***Shielding*** considerations may influence the location and arrangement of irradiation rooms. In the design of the rooms, several factors should be considered, among them:

- Type of ***sources***, their location, and the characteristics of the radiation beam
- Workload and use factors
- Purpose for which adjacent areas are used and occupancy factors
- ***Dose limits*** for the design
- ***Shielding*** materials

Shielding fulfills an essential function in every radiology service. Radiation ***sources*** have their own ***shielding***, which should meet mandatory design requirements for ***sources*** and be guaranteed by the manufacturer. Structural ***shielding*** needs should be calculated for each installation. Mobile ***shielding*** and leaded aprons play an important protective role in certain applications, such as fluoroscopy.

8.10.1.1 *Controlled Areas*

Access to areas in which radiation ***sources*** are used or stored should be limited to those personnel who are strictly necessary and are authorized to conduct ***practices*** in these areas. Appropriate safety and signaling systems should be utilized to restrict access. These areas are called ***controlled areas***. Access is restricted not only to avoid unnecessary ***exposures*** but also to prevent ***accidents*** that could be caused by people who lack the necessary expertise.

Safety devices (interlocks) should be installed when it is necessary to prevent anyone from entering a ***controlled area*** while patients are being irradiated.

8.10.1.2 *Supervised Areas*

Supervised areas are areas that have not been designated as ***controlled areas*** but for which ***occupational exposure*** conditions are kept under review. Specific protective measures and safety provisions are normally not necessary.

8.10.2 Specific Requirements

8.10.2.1 Diagnostic Radiology Services

Structural ***shielding*** should be adequate to protect the public and staff. ***X-ray*** machines should be equipped with appropriate accessories to reduce unnecessary ***doses*** of radiation to patients. The recommended radiological techniques for reducing patient ***doses*** should be used to obtain and process films.

In order to protect the operator, the equipment controls should be located within a shielded booth or area so that the operator is obliged to operate the machine from within this area. The booth should have a shielded window to allow the operator to easily see the patient. Oral communication between them must also be ensured. When the operator's presence in the radiation room is imperative, he/she should use personal protection elements such as leaded aprons and leaded gloves. Should a patient need to be physically supported or held during a radiological examination, this function should be performed by someone accompanying the patient who is not occupationally exposed and who is not pregnant. The ***exposure*** of this person should considered a ***medical exposure*** and should be constrained to 5 mSv per application (*26*). In such cases, all available protective resources, such as a leaded apron, should be utilized.

Mobile equipment is often moved into rooms in which people other than the patient may be present. As a result, special care should be taken in the collimation of this equipment, and it should be placed at a sufficient distance from other people who cannot be removed from the room while radiographic images are being taken. The operator should be positioned outside the direct radiation beam at a distance of not less than 2 m from the patient and should wear a leaded apron (*71*).

The procedures that expose radiologists and patients to the largest ***doses*** of radiation are fluoroscopic procedures, especially in interventional radiology, in which the physician utilizes fluoroscopic procedures and/or cinefluorography as a guide during surgery.

Dentists should take precautions with regard to their location at the time radiographic films are taken. They should not hold films in place with their hands, but rather should use special devices for this purpose or should ask the patient to hold the film.

With respect to patient protection, ICRP Publication No. 34 (*72*) contains abundant information on equipment and appropriate techniques to reduce unnecessary ***doses*** of radiation. WHO has also published guidelines for the rational use of radiation in medicine, which include methods for reducing unnecessary ***doses*** to patients (*7, 8*).

The most important features for this purpose are (*26, 70*):

- Radiation beam collimators and/or ***shielding*** for organs
- Beam filters
- Highly sensitive films and intensifying screens
- Non-absorbent structural materials between the ***x-ray*** tube and the patient (carbon fiber)
- High-voltage techniques
- Appropriate film processing techniques

8.10.2.2 Radiation Therapy Services

The ***sources*** used in external radiation therapy are high-***activity sources*** in the case of cobalt therapy units or high-intensity ***sources*** in the case of ***accelerators***. These ***sources*** produce high ***dose*** rates, which necessitates careful design of the installation and, especially, of the structural ***shielding***. Appropriate placement of radiation room helps to reduce the investments needed for structural ***shielding*** (for example, location of the room so that the surrounding areas have a very low occupancy factor and are inaccessible to the public).

Safety systems should be designed to prevent irradiation from accidental entry by ***workers*** or the ***public***. The doors to the room should be equipped with interlocks that function automatically during irradiation.

The equipment control booth should be positioned so that the operator can control the access to the room and see the patient who is undergoing treatment. It is advisable to have two visual monitoring systems—for example, a viewing window with leaded glass and a closed-circuit television system.

Another important aspect of radiation protection is the correct disposal of spent ***sources***, which is essential in order to prevent serious ***accidents*** like those that have occurred as a result of improper disposal of ***sources*** (*68, 69*). ***Sources*** which are no longer to be used should be disposed of in facilities equipped to handle this type of ***radioactive waste*** and in accordance with existing standards in each country.

Equipment should be kept in good working order and should be properly calibrated. Each treatment should be planned by personnel with specialized training in medical physics, and the service should have the variety of equipment necessary to ensure the most appropriate selection for each case. ***Quality control*** of the mechanical and radiant characteristics of the equipment should also be ensured (*65, 66*).

Correct application and continual updating of the computer programs used with the equipment and in treatment planning are equally important.

In brachytherapy services, appropriate design and ***shielding*** of patient rooms is of utmost importance, as is appropriate storage and transport of radioactive ***sources***. The insertion of radioactive ***sources*** into patients should be carried out by manual or automatic afterloading systems, which make it possible to considerably reduce the ***doses*** to operators.

Radiation therapy services need to have radiation detection instruments for radiation protection and precision instruments for dosimetry.

In addition to specialized medical personnel (radiation oncologists, radiation therapy technologists), radiation therapy installations should have the services of a medical physicist with experience in dosimetric calibration techniques, treatment planning, equipment ***quality control***, and radiation protection (*26*).

ICRP Publication No.44 contains important recommendations on the most effective means of approaching treatments so as to achieve better health results for the patient (*73*).

8.10.2.3 Nuclear Medicine Services

In the design of nuclear medicine services, independent rooms should be provided for the preparation of radiopharmaceuticals, storage of radioactive material, inoculation of patients, use of instruments, waiting room for patients, and meeting room. Special bathrooms may also be provided for patients. In order to prevent ***contamination***, the work surfaces, floors, and walls should not be porous or absorbent and should be easily cleanable. Exhaust hoods should be installed in the rooms in which radiopharmaceuticals are prepared. ***Radioactive waste*** should be disposed correctly.

Equipment such as ***radionuclide calibrators*** should be available to accurately determine the ***activity*** of radiopharmaceuticals to be administered to patients, and ***quality control*** programs should be implemented *(26)*.

ICRP Publication No. 52 contains important recommendations for the protection of patients in nuclear medicine *(74)*