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ENGINEERING STANDARDS AND REQUIREMENTS FOR RADIATION PROTECTION IN DESIGN OF DIAGNOSTIC AND THERAPEUTIC RADIOLOGY UNITS

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ABSTRACT

The aim of this study is directed to the application of engineering standards and requirements in the design of diagnostic and/or radiation therapy units. These requirements shall be fulfilled by the architectural perspective for the protection of workers and patients without unduly limiting the beneficial practices of radiation exposure. Therefore, the different functions of ionizing radiation units must be integrated with engineering elements in specialized treatment diagnosis. The study reveals deficiencies in some analytical cases. The weakness of radiation safety in the design is evaluated compared with standard requirements. According to the engineering requirements and standards the different elements and functions in these units are rearranged.

INTRODUCTION

Nuclear Medicine is a branch of medicine that uses radiation to provide information about the functioning of a person's specific organs or to treat disease. In most cases, the information is used by physicians to make a quick, accurate diagnosis of the patient's illness [1]. The, patients are exposed to ionizing radiations when they undergo diagnostic examinations using x rays or radiopharmaceuticals, therapy of cancer or benign lesions using radiations emitted by radioisotopes or those by radiation generators [2].

Accordingly, patients are exposed to ionizing radiations when they undergo diagnostic examinations using x rays or radiopharmaceuticals, therapy of cancer or benign lesions using radiations emitted by radioisotopes or those by radiation generators [2]. Higher doses can cause varying side effects during treatment (acute side effects), in the months or years following treatment (long-term side effects), or after re-treatment (cumulative side effects). The nature, severity, and longevity of side effects depends on the organs that receive the radiation, the treatment itself (type of radiation, dose, fractionation, concurrent chemotherapy), and the patient [4]. The consequent incorrect use of these machines increases the mistakes and incorrect doses. Clinical examinations should be performed with the lowest achievable radiation dose to the patient, consistent with diagnostic quality [3].

The philosophy of the use of engineering space is serves for two main purposes. The first is considered for accessing maximum efficiency of the work. The second is concerned about the safety of the patient. Some of the shortcomings in the radiology departments in hospitals, caused by non-specialist architectural designer, cause an over-radiation exposure of patients, staff and visitors. The over dose can be resulted from; 1) radioactive leakage from the devices used or exceeding the limits of the radiation dose to workers or to the public, 2) the lack of adequate protective barriers, 3) flaws in the architectural design.

The present study put the light on some analytical cases to evaluate the weakness in the protection and safety in the diagnostics units. Additionally, the study tries to explore the engineering shortages and find solutions depending on the safety design requirements.

STANDARDS DESIGN REQUIREMENTS

In order to find out the engineered discrepancies, the different cases considered shall be compared against three measures: 1) international safety requirements, 2) optimum design based on the international requirements and 3) distance around injected patients.

The international safety regulatory requirements are identified in Table 1. The table is clarified the appropriate distribution of space and its dimension. Additionally, Table 2 is listed the standard specification of barriers needed for various radiation source used in hospitals.

Table 1. Standards and requirements of architectural design [2]

Figure	Detail
1	Ray room area of not less than 15 square meters
2	Though room or designated though area of 2 square meters at least
3	A place to change service area of 1.5 square meters at least
4	infrared device
5	Ray table with a barrier wall chart
6	Comment rack doors with bullets
7	Shield
8	Install the patient tools
9	control panel and movies
10	Emergency stretcher
11	work table with seats
12	Safety light rays to preview
13	tray to help the patient to get to the table

Table 2. Specifications of Preventive Barriers

Rooms type x-rays	Vacuum space *	The thickness of the protective barrier of radiation ***
mammography	3,05X 3.05 meters) 9,29 square meters)	3.20 cm of plaster wall panels. 0.3-0.8 mm bullets
Automated chest unit (with film processor)	4,27X 6.10 meters) 26.1 square meters)	
alminar is sectiontomography radiographic unit	5,18X 7.32 meters) 37.9 square meters)	0.5-1.0 mm bullets
fluoroscopic unit	5,18X 7.32 meters) 37.9 square meters)	0.75-1.5 mm bullets
Bi-diagrams may specialprocedures (With digitalradiography)	6.40 X 7.32 meters) 46.8 square meters)	0.5 -1,6 mm bullets 8-15 cm concrete
CT scanner floors and ceillings	7.62X 12.2 meters) 93 square meters)	
	9,14 X 10.7 meters) 97.8 square meters)	

According to the tables 1 and 2, the optimal design for the radiology department shall be in the forms shown in Figure 1 and Figure 2. The design demonstrates good distribution of specialties, separate entrances for patients who were injected, existence of waiting rooms entrances curve, separate toilet, and distribution of diagnosis and treatment sources from low to high radiation.

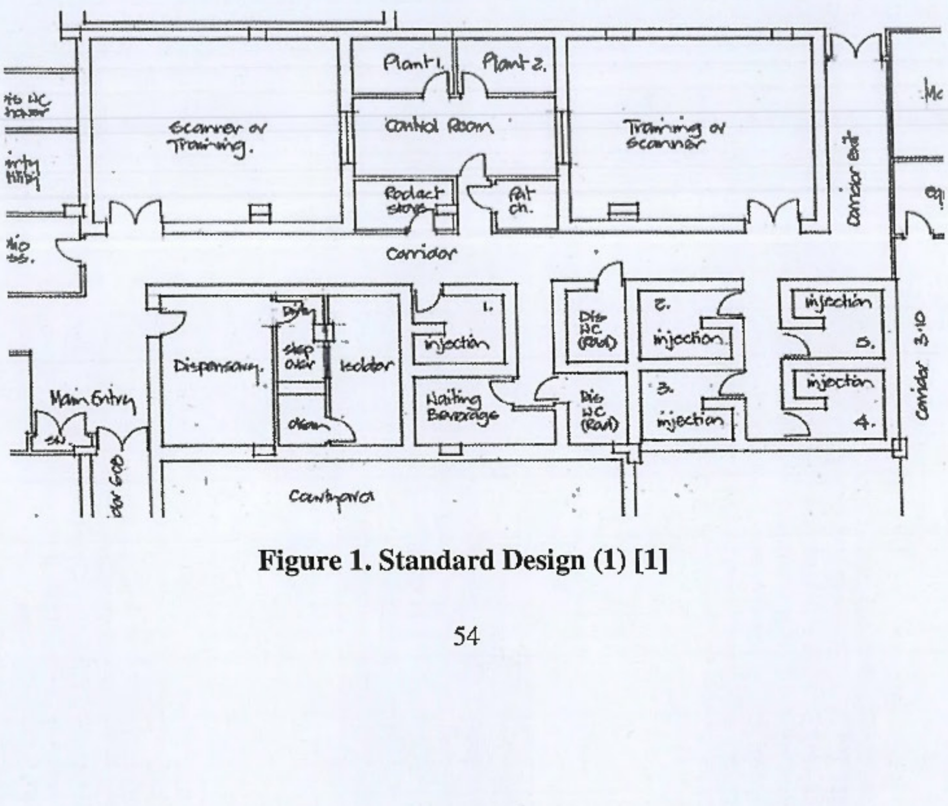

Figure 1. Standard Design (1) [1]

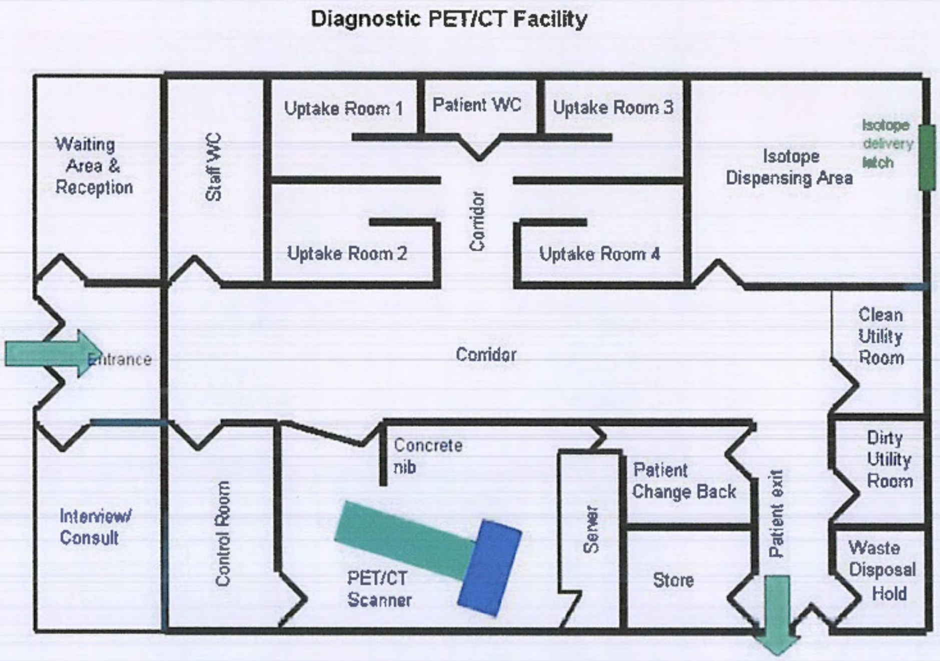

Figure 2. Standard Design (2) [2]

The distance around injected patients has been studied to calculate the emitted doses in the different zones as shown in Figure 3. The figure indicates the prohibited area surrounding the patient. These zones can have an impact on the other patients existed in the same area and workers. Each patient will exposed to various doses rate in addition to his own injection rate. Therefore safe distance shall be considered in the engineering design, to achieve the appropriate radiological protection.

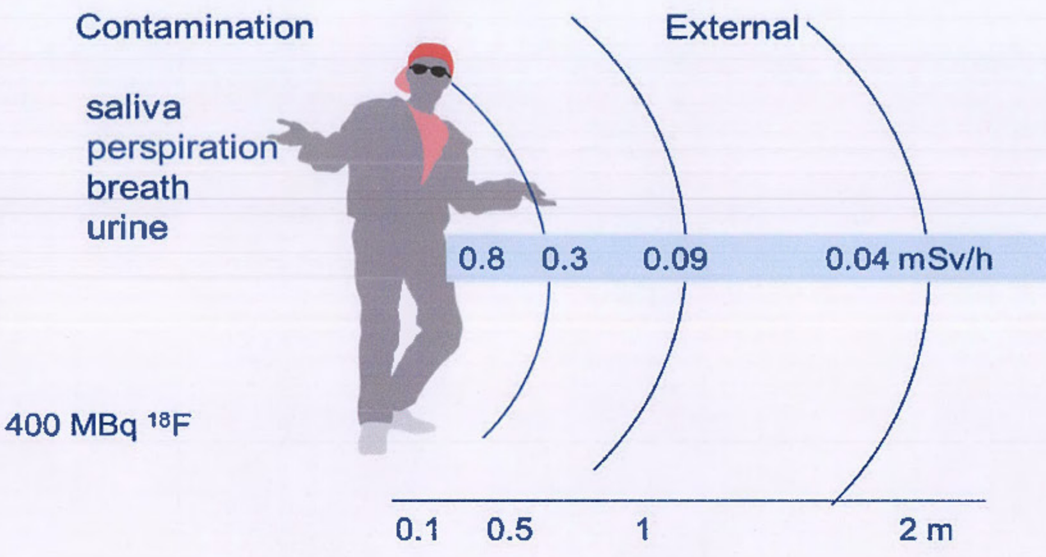

Figure 3. Radiation dose rates from patients undergoing PET: Eur J Nucl Med 2000: 27: 583-9

CASE STUDIED

Different models in some hospitals have monitored and some cases show poor engineered design that need to improve for achieving maximum protection from radiation.

Case (1)

First deficiency is detected in the bad location of patients waiting rooms. It is not follows the international standards and requirements (Table 1 and 2) in; the dimensions and the relationship between the rooms and sections, the direction of the entrances and exits, and places of preventive barriers.

Secondly Poor efficiency of radiation protection requirements authorized by the competent authority, and the lack of sufficient knowledge and experience to the appropriate officials for some protection from radiation.

Third the study reported that some hospitals do not select the appropriate location of the department, in terms of its distance from some sections densely workers such as lab and pharmacy. Alerted to the need to take care of the regulator to monitor hospitals and reviewing engineering design, and not install-ray equipment or change locations without reference to the hand competent.

The following is a study of engineering design of X-Ray Departments, that suffer from inadequate in engineering design criteria.

- Study and analyze problems of engineering design

(Figure 4) shows the measurement of exposure levels for workers is very high, and conduct monitoring found they are subjected unjustifiably radiation doses with extra time every day, as well as the increase in the number of patients requiring an increase in the shielding or re-design and distribution of the workplace to reduce exposure to high doses of radiation. The study concluded that the most important flaws in this design:

- The direct line between places waiting patients (during the critical period) and places workers break.
- There is no room for control and protection for workers.
- The high rate of exposure due to bad distribution and thus increase the dose of others justified.
-facility design, money spent by International Energy Agency

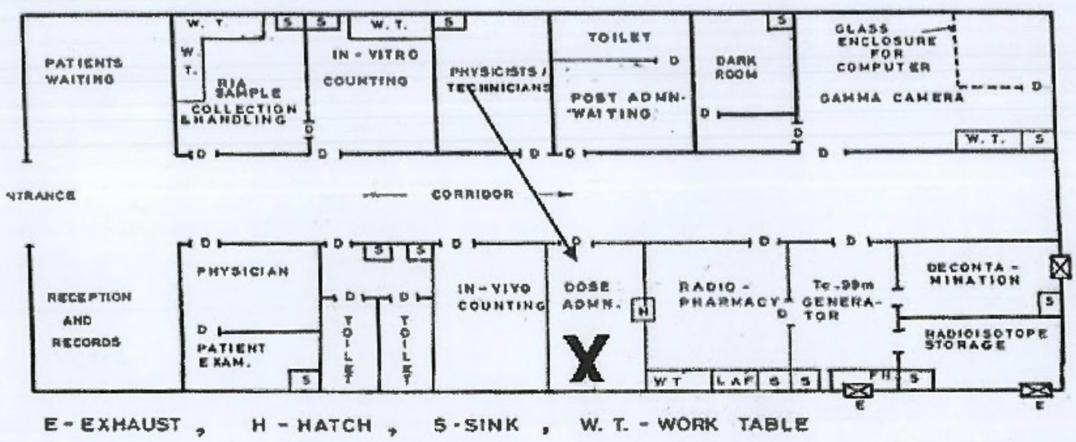

Figure 4. Muscat horizontal one study samples shows the distribution of non-true elements of Radiology section

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Possible Solution: Due to the difficulty of the radical change in current design and by reference to the standards and requirements, it was found that the ideal solution is to control the distance between patients from other persons. Based on, the proposed solution is the transfer of waiting room to the farthest point. So that they can be far from the places of workers, and away from the paths of traffic, and at the same time surrounded by free spaces as shown in Figure 5.

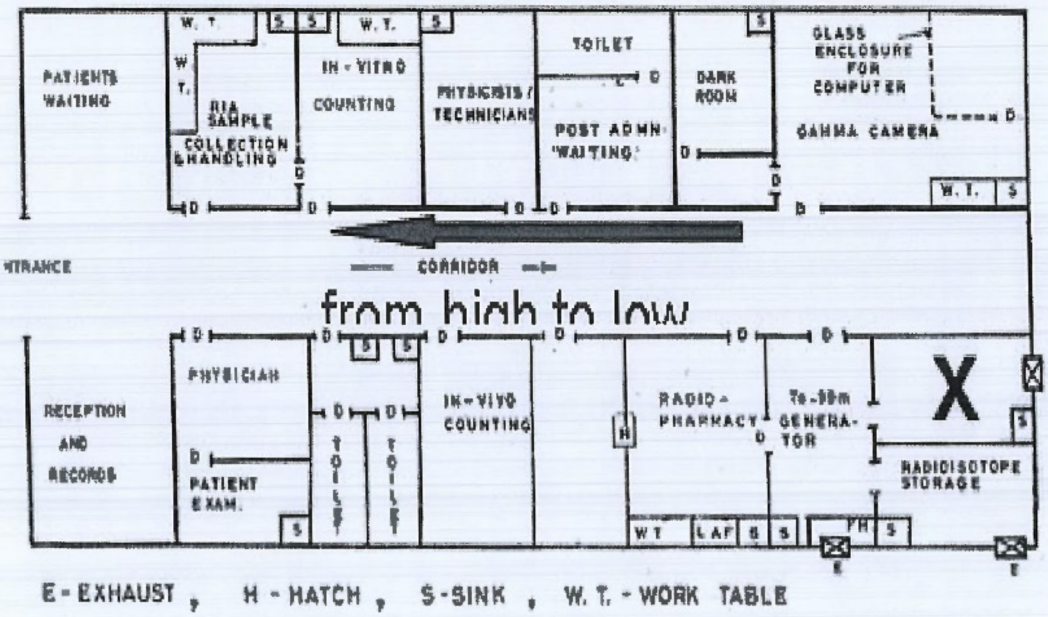

Figure 2. Modified Design Based on the International Requirements.

Figure 5. From the above mean study the work of analysis of engineering areas and motion paths, that are supposed to be the study samples in an attempt to reduce exposure, and to meet the requirements and standards of preventive International. And following analysis simplified motion paths and the relationship of the components section. (Figure 6 a)

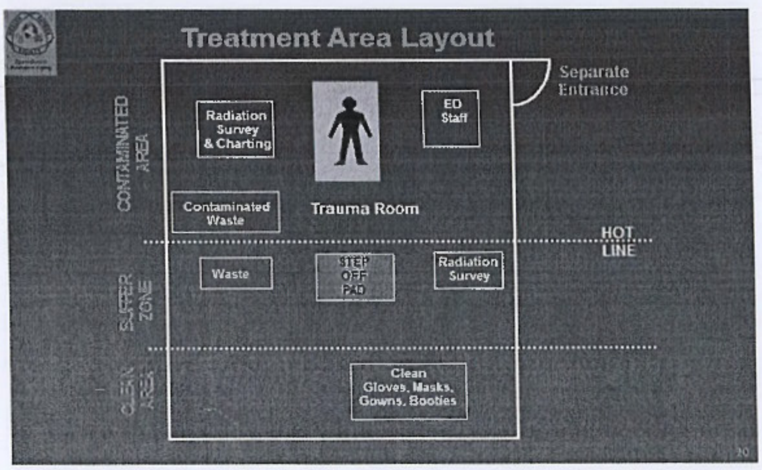

Figure 6. Models of distributed engineering designs for diagnostic units

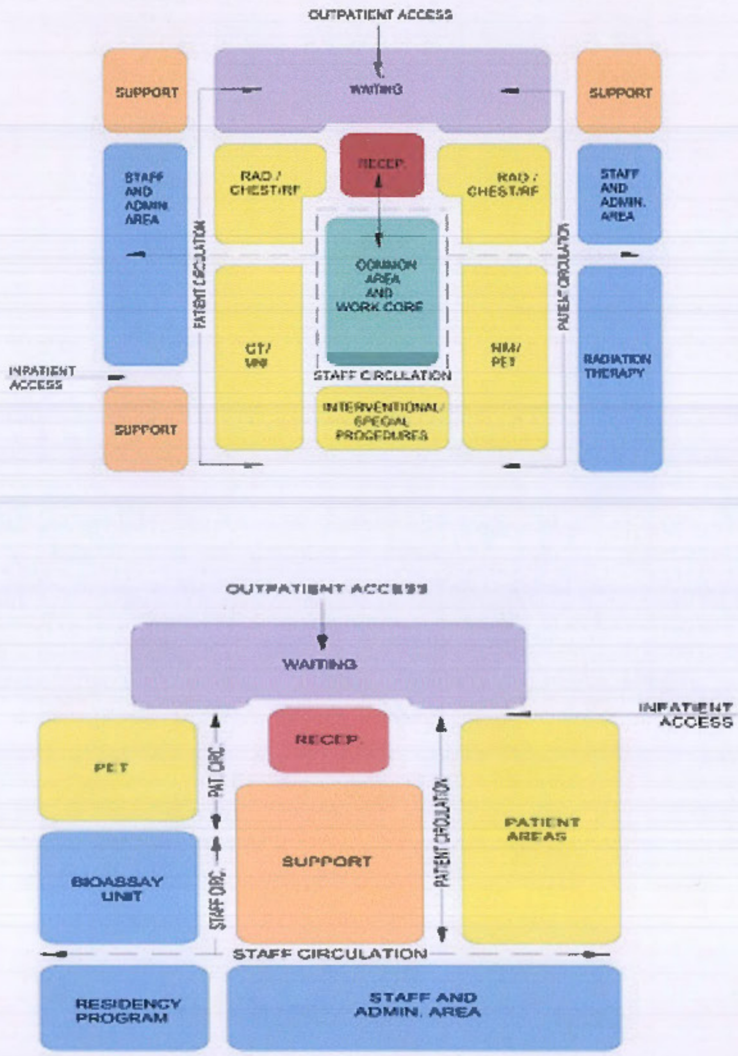

Figure 6a. radiology service area relationship by modality

Thus it was to reach an appropriate adjustment to get the maximum protection, and reduce exposure to a dose of others justified for patients and staff (Figure 4-4 a), through the redistribution of the elements of the radiology department, so that the areas of high radioactivity in the side furthest with less frequently used, so that the traffic high in the region in less exposure limits.

And the completion of the analytical study, the study recommended that there should be engineering requirements of the following review and compliance with reality basically, for example in one of the types of sections scan,(CT-unit Diganostic PET /) be the walls thickness of 6 inches of concrete, or 9 inches if they are brick, if bricks hollow, they must be placed above the lead, or be coated pariom, and have double door of the main entrance, and the door of a room acidification equipped with a shot, and put lights warning red on the main door, and also placed posters warning of radiation in the appropriate places.

The above review and study, it was reached to the engineering requirements for the design of the radiology department, to reach to maximize for the Protection of radiation.

Table 3. Architectural interior design requirements for radiology department

Figure	The conditions
1	could be the establishment of the Center in a separate building or in a building that is available at least one elevator in the building that was the Center for first role and above, can also create a private hospital or the center daily cases or medical complex or specialized clinics
2	Required provides daylight and proper ventilation in the clinic on the soft screen is available for Windows that can be opened
3	The walls are painted paint suitable to be smooth, and not intense aspects that the floors are of an easy cleaning (for example ceramic floors or Special Medical).
4	The doors of the rooms and corridors to allow easy movement of the wheelchair (the entrance doors at least 90 cm and corridors not less than 120 cm).
5	Designated to receive patients
6	An appropriate place waiting for men and another for women
7	The doctor in charge at the center is equipped with infrared lamp suitable X-ray viewer
8	X-ray room size of 20 square meters (at least) to at least the entrance to the room of 120 cm and at least up to a height of 2 meters
9	Designated to change service area 1.5 X 1 meters at least connected with the imaging room.
10	Room size though at least 2 square meters (or designated for developer).
11	A room for the ultrasound imaging area 6 square meters at least on the Bed with custom scrutiny.
12	will provide services in CT or magnetic resonance imaging or breast or nuclear medicine services or any other services, advanced devices to provide copies of files for the required specifications of the prevention of radiation for each device
13	Water cycle number 2 on at least one of them for men and women (preferably a water cycle near rooms photography).
14	Designated files, medical records.
15	chemical substances store movies that are available on the proper ventilation
16	The corridors of accessibility in the building.
17	Is required to be available in the building conditions of security and public safety, with the availability of fire fighting.

And with the need to develop a clear program and the sequential steps of repair and maintenance, according to the manufacturer's recommendations and programs designed to educate visitors, and create a documented emergency plan compatible with the design so that the decline Engineering and development on a regular basis. With adequate training for employees on the implementation of the emergency plan are to enable them to avoid the danger, not only the study only on sections of diagnostic radiation, which alerted to the presence of a number of irregularities in some sections, in terms of the lack of appropriate place for temporary storage and final storage, dimensions required ventilation and study motion paths for entry and exit and arrange storage of radioactive waste, as well as ventilation and resealed place, in addition to the same errors in the aforementioned sections rays Has been reached.

The study called for fast processing of a number of irregularities in the study, and conduct a security assessment by qualified expert before any adjustments in some sections, and insufficient radiometric survey fixed to scan and monitor areas monitoring radiation, as well as mechanical to close the doors and provide a means of communication within the treatment room.

The study found that the status quo in health facilities using radioactive materials is the lack of safety standards and monitoring, requires a comparison with international regulations in a number of developed countries with a view to finding a basis for recommendations control.

CONCLUSION

The aim of this study is to correct some of the conditions, in some designs places of treatment and diagnosis of radioactivity.The study showed that the majority of sections diagnostic or treatment radiation in the study sample, did not achieve the licensing requirements to practice radioactivity by the competent authorities in the protection of radiation, for example the finishing, ventilation, preventive and shields of radiation protection, the study also noted:

We note from this study that the establishments and departments that did not take into account the requirements and engineering standards for the use of radiation in the treatment and diagnosis, leading to the exposure is not justified for workers or patients or the public, and therefore we recommend the application of the standards and requirements must be taken into account when getting a license for these sections. The sections that were reviewed met these criteria, and it turns out work safety and radiation exposure levels exceeding the border in accordance with the criteria in the law regulating nuclear and radiological activities for workers and the environment and the public. In view of the seriousness of this type of environmental pollution, the architectural conditions shall be in the licensing requirements to prevent or reduce of radiological impact. It should be noted after a review of previous studies, importance of avoiding the damage from radiation by several solutions, expense of the distances and materials used, and control the time of exposure to radiation, applying the rules and principles of prevention preventive radiological, and barriers that are designed to suit the nature of the radioactivity.

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