Journal of Radiation Oncology & Research

Research Article

Low Frequency Magnetic Field in a CT Area

Yenisel Díaz Roller[1], Janet Carvajal de la Osa[1*], Ignat Pérez Almirall[1], Alejandro Rivas Gamallo[1], Miguel Castro Fernández[1] and Iosvany Aguiar Ramos[2]

[1]José Antonio Echeverría Technological University of Havana, CUJAE. Havana Cuba

[2]Center for Biomaterials, University of Havana, Havana Cuba

Abstract

Introduction : Throughout history it has been proven that electromagnetic fields at uncontrolled levels can be harmful to health. The Computerized Axial Tomography (CT) is a high electromagnetic field generator. In TAC areas where workers are exposed to these radiations for extended periods of time, it is necessary to keep not only ionizing radiation under control, but also non-ionizing radiation.

Goals: Carry out magnetic field measurements in a CT area in a hospital in the city of Havana, compare them with international standards and check the state of the electromagnetic environment.

Methods: The magnetic field measurements were carried out using a gaussmeter located one meter above the floor level and punctually meter by meter. To verify the state of the environment, the recommendations of the International Commission on Non-Ionizing Radiation Protection (ICNIRP) in 2010 were used as a point of comparison.

Results: The results showed values below those recommended by the ICNIRP, but very close to those provided by some authors as causing leukemia.

Conclusions: It was concluded that the non-ionizing radiation values obtained in μT do not exceed those recommended by this commission, with respect to occupational exposure, but strict surveillance must be maintained.

KEYWORDS: Electromagnetic fields; Occupational exposure; Computed axial tomography

Introduction

Radiation is a controversial point in the safety of work in imaging departments in hospital institutions. These take into account the dose of ionizing radiation absorbed by workers in order to protect their health and promote safety and labor protection standards.

Computed Axial Tomography, better known as CT, is a medical imaging test used to diagnose a disease, plan a treatment, or determine if a treatment is effective [1].

Electromagnetic Fields (EMF) are generated only when electric current flows [2]. In the case of imaging departments, especially in CT scans, electromagnetic fields and X-ray radiation coexist in the environment of the electrical device, both considered by the World Health Organization (WHO) as harmful agents. These above certain thresholds can trigger biological effects, harmful in the short or long term, and in some cases reversible with or without visible consequences.

Electromagnetic fields generated by low frequencies are considered the cause of different diseases such as leukemia, hormonal disorders, and immunosuppression, among others [3]. The first work carried out on the biological effects caused by them took place in the former Soviet Union where scientists led by Korobkova VP et al. [4] observed strange alterations in electrical workers exposed to high levels of electromagnetic fields, expressed in diseases. heart problems, blood pressure alterations, recurrent headaches, fatigue, stress and chronic depression. A few years later, a group of Canadian scientists determined that a high percentage of the workers who handled the radars suffered from or became ill with leukemia, determining that the cause of the disease was the combination of radiofrequency radiation and electromagnetic radiation at which were exposed [5].

Hospitals are an excessive source of electromagnetic field emissions because technology has overwhelmed the health sector and its development is increasingly advanced. This has been evidenced by measurement and interference work, where not only the individual scope of the equipment is observed [6], but also the effects that the emissions of some on others due to their proximity [7,8].

Although manufacturers take into account the values regulated or recommended by institutions when exposing medical equipment to the market, it must also be taken into account that the operating time of medical equipment is not established as a rule to follow, but as a commercial standard. Many works over the years have focused on verifying that the short wave [9-11], rehabilitation [6,12] and magnetic resonance [13,14] equipment used in the health system at the national level worldwide, are suitable for use based on the magnetic field they emit and maintain during their operation. The conclusions affirm that they do not pose a danger to the patient, but they do pose a danger to the operator or technician who uses it due to the proximity and frequency of interaction with it. This is based on the work carried out by Choi S, et al. [15] who determined that the worker related to the assembly and testing of semiconductors whose exposure is between 0.56 and 0.89μT is the most affected, thus verifying that direct contact with the Magnetic field generators affect people's health. Which has brought with it a proposal to review the levels recommended by the ICNIRP, especially for workers in the healthcare imaging specialty [16].

Definitely the study of electromagnetic fields is a problem that cannot be dismissed. Its analysis is a fundamental tool to take into account for risk management. In an imaging department where the diagnosis is made through equipment that emits radiation, whether workers do not suffer damage to their health depends on the radioactive environmental load, work and rest time, and the genetic physical conditions of the workers. workers. It is for this reason that since there is no standard in Cuba that regulates the emission of magnetic fields in hospitals, it is necessary to measure and verify the electromagnetic

Submitted: 31 January 2024 | **Accepted:** 15 February 2024 | **Published:** 18 February 2024

***Corresponding author:** Janet Carvajal de la Osa, José Antonio Echeverría, Technological University of Havana, CUJAE. Havana Cuba

Citation: Roller YD, Carvajal de la Osa J, Almirall IP, Gamallo AR, Fernández MC et. al, (2024) Recurrent Radiation-Associated Breast Angiosarcoma. Report of a Case with Uncommon Clinical Presentation and Brief Review of the Literature. J Radiat Oncol Res 4: 6.

environment in which the workers live, as is the objective of this work, taking into account internationally regulated levels for the prevention of occupational diseases.

Materials and Methods

Materials

A SOMATOM Sensation 64 CT scan, an EMDEX II gaussmeter and a tomographic testing area of a hospital in Havana were used.

The CT equipment has 64 slices, capable of taking 192 images of organs per second. Within his routines of use, the radiologist, before starting the first diagnostic service, must calibrate the equipment and this action lasts approximately 20 minutes. Imaging takes approximately 10 minutes longer. This model has a basic configuration that includes a STRATON0.33*; 0.37; 0.5; 1.0s. Extended scanning field of 50 cm, 70 cm, among other features.

To make measurements of the area of imaging It will be used an EMDEX II brand gaussmeter. It has three coils located inside the meter to record the magnetic field density of each axis (Bx, By, Bz). This magnitude is recorded by the microprocessor that calculates instantly and in real time with a maximum of 1.5 seconds, the resulting magnetic field from the magnetic field readings of each axis. Among its technical specifications we can mention a range of 0.1 to 3000 mG (0.01 - 300 µT), it has a resolution of 0.1 mG (0.01 µT), a typical precision ±1-2%, frequency with a bandwidth between 40 to 800 Hz, with harmonic between 100 and 800 Hz. This equipment has a small digital screen as a graphical interface where the values can be read at the point where it is located, as well as an internal memory to save them.

Methods

To carry out this work, a measurement protocol was developed based on standards [17,18] and consulted works [19-22] considering the dynamic characteristics of the Imaging service where the study was carried out, which was divided into three stages.

1. Characterization and measurement of each location.

2. Calculation of average exposure levels for the job.

3. Comparison of the daily and annual average values calculated with the levels regulated by the ICNIRP 2010.

Methodology to carry out measurements

To characterize the electromagnetic environment of the studied premises, measurements were carried out once a week for 21 days. This work strategy was taken due to the epidemiological conditions derived from the pandemic caused by the SARS-CoV2 virus. The measurements were carried out with the air conditioning equipment and the lights on at all times, in three different phases presented below:

- Phase 1: CT off.
- Phase 2: CT on without working.
- Phase 3: CT on working.

The measurements in phase 3 were only carried out in the areas where workers must remain during the operation of the CT, due to the Cuban protocol on work hygiene and epidemiology for CT zones or areas [18].

The geometric measurement (length by width) corresponding to each room to be studied was carried out: operator's cabin, diagnostic reception room, central hallway, CT technological equipment area and nurse's room to build the sketch of each room in 2D. In these, the location and arrangement of electrical equipment inside each area during the measurement days were recorded.

The environment under investigation was divided into an imaginary mesh with intersection points 1 m away from each other. The measurements were made at these points at a height of 1 m above the floor level, always clockwise, see figure 1.

Procedure for calculating the average annual exposure level for a job

Health workers spend most of the day at their workplace and not at home. The quality of the assessment of occupational exposure

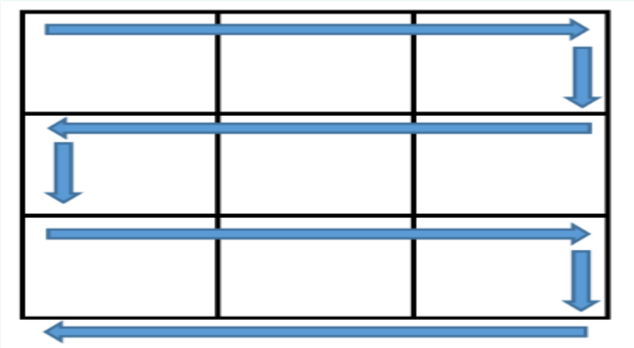

Figure 1 Tours carried out in the studied premises of the imaging service.

will depend on the details of the history and type of work. The more identified the task and the time in which a worker works, the calculation of cumulative exposure could be expressed in µT per year based on the fact that exposure to the magnetic field in a specific work environment becomes more evident, in a specific workplace [23]. For this reason, the average exposure level was calculated for a year of work in the operator's position and the diagnostic area, under normal conditions and under current conditions (COVID-19), where the influx of patients depends of the number of cases that occur on the day, using equation (1) set out below.

$$B_c = \frac{B(t) \cdot h' \cdot d'}{h \cdot d} \qquad \text{--- (1)}$$

Where:

B(t): average magnetic flux density,

h': number of hours per working day,

d': number of working days per year,

h: 24 h,

d: 365 days

Results and Discussion

Results

For the study, only five premises were taken into account and the corridor that leads to said premises that are adjacent to the CT, as shown in figure 2, the somaton (CT) is marked in a red circle and in table 1. The technological equipment of each location is broken down.

The color mapping of each measured area was obtained and its corresponding scale is shown, in mG, which reflects the average results obtained from the measurement for each phase, according to the measurement conditions addressed in the methodology, see figures

Table 1: Equipment of the studied areas

Operator's Cabin	1 Split, 3 monitors, 1 database tower, 1 dehumidifier
Diagnostic reception location	1 Split, 1 backup, 1 dehumidifier, 1 flat monitor, 1 desktop computer.
TAC area	*1 Somaton 64* (CT), 1 Split, 2 dehumidifiers
TAC technological equipment area	1 Split,1 TAC power supply, 1 cooling system
Nurse's Room	1 refrigerator, 1 microwave.

3,4.

Table 2 shows the general averages obtained for each location, taking into account the phases measured in each case and the three days in which the measurement was carried out.

According to Ruz Ruiz M, et al. [23] if it is based on a single type of work and we identify the type of task being performed, it can allow

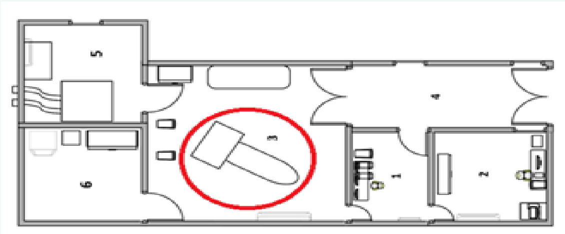

Figure 2: Plan obtained from the studied area

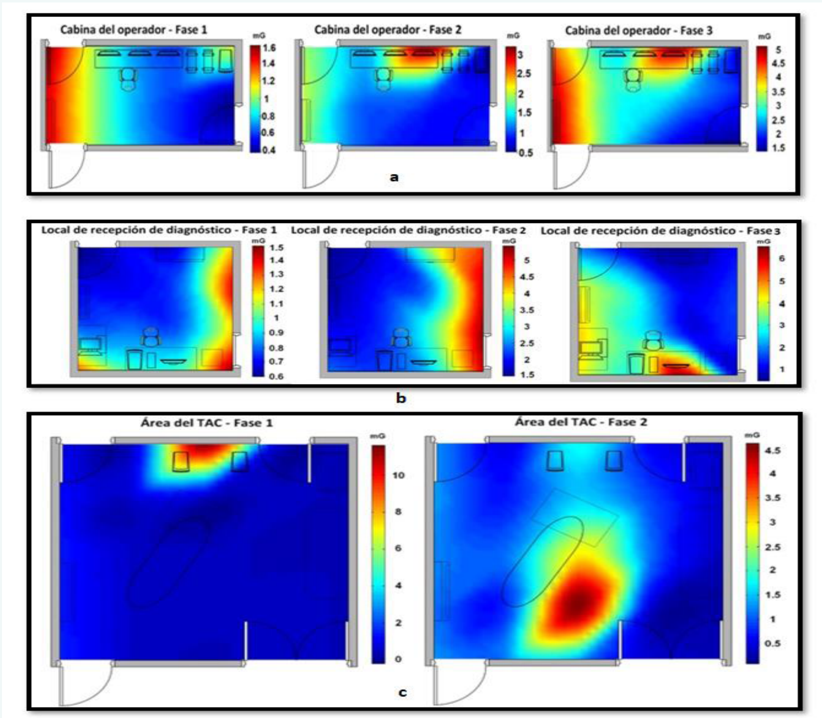

Figure 3: Graphic representation using colors of the average magnetic field values of a- operator's cabin, b- diagnostic reception area, c- CT area.

the calculation of the cumulative exposure of a specific individual by expressing it in µT per year. In this work environment it is possible to estimate, as a dose, the contribution of the magnetic field at an average exposure level based on equation (1) expressed in the materials and methods section. When performing the calculations, the values presented in table 3 were obtained. These represent the average exposure for 1 year of work under the conditions presented above. The calculation was only carried out in these locations because they are the ones with the longest stay of workers.

Discussion

The results obtained show, through color maps, the different areas where the magnetic field acts. The highest values achieved can be identified by the color red. It can also be observed that there were some areas where the measurements were carried out only in two phases, this was due to the fact that it is not allowed by the occupational safety and hygiene standard in Cuba [18], to access the area when the tests are being carried out.

The places where measurements were made in the three phases were the operator's cabin and the diagnostic reception room. In these areas it is observed that as equipment is put into operation, the values at each measurement point increase between 1.5mG (0.15µT) and 2 mG (0.2 µT) from one phase to another, reaching values of 6.5 mG (0.65 µT) in the premises where the operators are located during working time.

In the operator's cabin according to the color map, while the CT equipment is not turned on, the largest radiation zone is located in the place of the air conditioning equipment, but in the phase 2 and phase 3 measurements they appear above the operator's position of the CT.

In phase 3 the measured value increases 2 mG (0.2µT) when the air conditioning equipment comes into operation, which verifies that the EMF increases when the values of one source close to the other converge. Among the problems detected with respect to the control of radiation leaks, it was stated thator there was airtightness in the protective glass against these, because there is a separation of one finger between the glass and the frame where a lead gasket should go, although in the case of electromagnetic fields the glass does not serve as shielding, if it were leaded, it would act as a container and minimize the level of ionizing radiation that passes to the other side of it and the incidence of SAR on the worker would be minimized.

In the diagnostic reception area, it can be seen that in phase 1 the highest value is found in the area where the air conditioning equipment and computers are located. Already in phase 2 this area of greatest radiation moves to the opposite side. This is because the CT power cables are located on the false ceiling in the aforementioned area and when you turn on the equipment and put it into operation, the electromagnetic

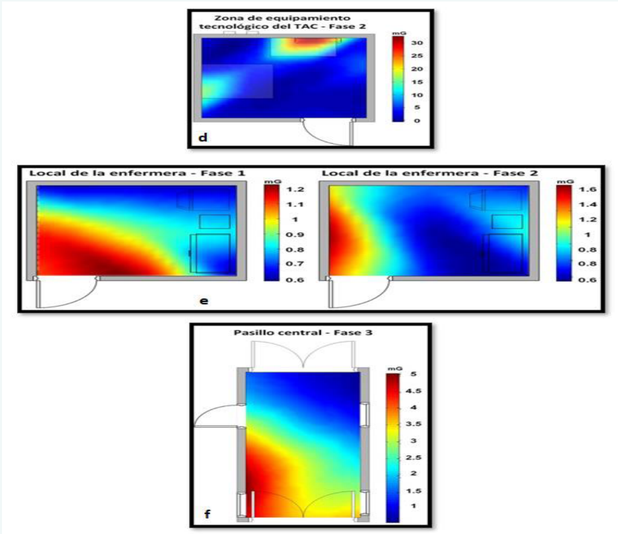

Figure 4: Graphic representation using colors of the average magnetic field values of d- technological equipment area of the CT, e- nurse's room, f- central hallway.

Table 2: Average values calculated in the measured areas.

Local	Values in mG	Values in µT
Operator's cabin (9 measurements)	1.791667	0.18
Diagnostic reception location (9 measurements)	2.122917	0.21
CT area (6 measurements)	1.06	0.1
Center aisle (6 measurements)	2.583333	0.26
TAC technological equipment area (3 measurements)	4.88125	0.49
Nurse's Room (3 measurements)	0.905556	0.09

Table 3: Average working exposure levels for normal conditions and current conditions in µT.

Local	Bc Under Normal Conditions (µT per Year)	Bc in Current Conditions (µT per Year)
Operator's cabin	0.05	0.082
Diagnostic reception location	0.06	0.096

fields are activated that begin to circulate through the environment. In phase 2 the highest value reaches up to 5.2 mG (0.52 µT) and in phase 3 up to 6.8 mG (0.68 µT), increasing the electromagnetic environment by approximately 1.5 mG (0.15 µT). of the area. In phase 1, in the lower left corner of the map, a yellow area is observed that corresponds to the magnetic field generated by the operation of the air conditioning equipment and computers. These values turned out to be high than those generally observed in this type of equipment, so attention was paid to the adjacent area because the electromagnetic fields are neither minimized nor shielded, much less contained by the concrete. When observing it, a large agglomeration of electronic equipment was detected, which it is unknown if it was in operation or not, but which does affect the measurement in the study area, providing an added value of between 0.5 and 1 mG (0. 05 and 0.1 µT), in each measurement phase.

In the CT area only, measurements were made in phase 1 and phase 2. If observed, the highest value obtained was in phase 1 equivalent to 11.8 mG (1.18 µT). This could be because the CT cooling equipment is located on the back of the wall adjacent to that point, which was in operation at that time. Already in phase 2, the value mentioned above disappears and the maximum value is transferred to one of the spaces close to the CT equipment with an equivalent of 4.5 mG (0.45 µT), in this case that value corresponds to a point where the cables are semi-buried without the required protection.

In the hallway the values obtained were only during the operation of the CT, the average shown in the mapping exemplifies maximum values close to 5 mG (0.5 µT), these values are due to the fact that the electric board is located close to the area, whose wiring is not buried, but rather passes through the false ceiling. This, in some unidentified part of the premises, enters the CT area underground and then rises to the ceiling inside the wall in the nurse's room where the map displays the red color equivalent to the highest point measured for any phase.

Of the values obtained during the measurement in the room where the technological equipment associated with the CT is located, the maximum value is equivalent to 32.6 mG (3.26 µT). This is equivalent to the magnetic field generated by the sum of the magnetic fields of the CT source and the air conditioning equipment, which are located at a distance of less than 50 cm, outside the minimum interference limits recommended by the manufacturer. The other ignition point found in the area had a value of 16 mG (1.6 µT) and belongs to the CT cooling equipment and we have already seen the influence it exerts on the values obtained in the TAC premises in phase 1. This influence will decrease as the distance between one team and another increases.

Under normal conditions, the staff continued to work 26 working days a month at a rate of eight hours a day. Currently, these have been divided into two groups that rotate through seven-day workspaces while remaining in the workplace. In this area it was found that the workers were equipped with face masks, gloves and in some cases face shields, intended for the containment of COVID-19, but in none of the cases were dosimeters or other devices measuring ionizing or non-ionizing radiation.

The values presented in table 3 are subject to variations, due to the dynamics of use of the electronic equipment that exists in these areas, which depends on the number of patients who require the technique to obtain their diagnosis. However, noting that, although the calculated values are below those recommended by the ICNIRP as exemplified in figure 5, under current conditions, even keeping the worker in the workplace for fewer days, he or she receives higher radiation values. annual.

Authors such as Carpenter DO, et al. [24] assert that radiation values of 0.2 to 0.3 μT contribute to the appearance of leukemias in people who spend most of their time near low-frequency magnetic field sources. Among the personnel who have worked in the department there has been mortality and suffering from some type of cancer, for example, lymphoma and breast. These conditions are linked to both ionizing and non-ionizing radiation, which is why it must be taken into account that magnetic fields, although they are a type of non-ionizing radiation, must be evaluated in the same way as radiation. ionizing.

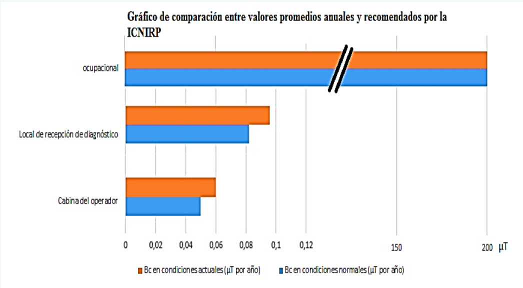

Figure 5: Comparison between average values of each location and values regulated by the ICNIRP 2010.

Electromagnetic fields, when they affect in a hidden manner, are not considered as sources of occupational disease in the areas of imaging, which is a mistake, since the short and long-term effects that develop in workers can be caused by them. Furthermore, these fields exert their influence on the body cumulatively, causing progressive damage.

It is for this reason that recommends establishing dosimeters for both types of radiation in these work areas, or maintaining strict surveillance over them, through periodic measurement of the electromagnetic environment.

Conclusion

The calculated average radiation values do not give rise to a danger signal for workers, when compared with the ICNIRP recommendations, although some exceed the values that are considered to cause leukemia.

In this work area, two types of radiation harmful to health coincide, so the measurement of both on a regular basis must be taken into account.

There is a greater risk of exposure to electromagnetic fields under current working conditions than under normal conditions.

References

1. Haro P, Hevia-Montiel N, López-Blanco X, Rosado-Vallado M, López-Valencia G, Waleckx E. Applications and potential of diagnostic imaging techniques in biomedical research of Chagas disease. Rev Biomed. 2021; 32: 45-54.
2. Alonso Fustel E, Garcia Vázquez R, Onaindia Olalde C. Electromagnetic fields and health. In electromagnetic fields and health effects. Basque Country. Subdirectorate of Public Health of Bizkaia. 2011.
3. Revueltas Agüero M, Gutiérrez Soto T. Extremely low frequency electromagnetic fields and their influence on human health: a controversial topic. Rev Arch Med Camagüey. 2017; 21: 672-682.
4. Korobkova VP, Morozov YA, Stolarov MD. Influence of the electric field in 500 and 750 kV switchyards on maintenance staff and means for its protection. CIGRE paper. 1972; 23: 9.
5. Mille A, To T, Agnew D, Wall C, Green L. Leukemia following occupational exposure to 60-Hz electric and magnetic fields among Ontario electric utility workers. Am J Epidemiol. 1996; 144: 150-160.
6. Deás Yero D, Gilart González F, Quintana Revilla D. Characterization of exposure levels to electromagnetic fields during diathermy treatment. MediSan. 2013; 17: 908-914.
7. Carvajal de la Osa J, Santana González J, Herrera Galán M, Sánchez Grau A, Pérez Almirall I. Environmental magnetic field in a neonatal intensive care unit. importance of its verification. Arch argent Pediatrician. 2020: e246-e251.
8. Aguiar Ramos I, Díaz Roller Y, Pérez Almirall I, Castro Fernández M, Carvajal de la Osa J. Characterization of electromagnetic interference in a neurophysiology room. Energy Engineering. 2020; 41: e0708.
9. Adasme Jeria R, Nazal Lama C. Measurement of the electric field intensity of the shortwave equipment in use in the Metropolitan Public Health Services of Kinesiology and Physical Medicine and Rehabilitation in 2003 and determination of compliance with the ICNIRP recommendation occupational. 2003.
10. Rodrigo García-Pando C, Granados Arroyo JJ, Mozo Blanco P, Furios Resa R, Goenaga Olaizola C. Exposure to electromagnetic fields in a rehabilitation service. Medicine and Occupational Safety. 2007; 2: 21-24.
11. Rasines Gómez A, Hernando del Pino LM, Ausín Canduela N, Albert Payá FJ, Garrido López Á, Gutiérrez RA. Study and evaluation of occupational exposure to electromagnetic fields in physiotherapy treatments, presented at the VI National Congress on Occupational Risk Prevention in the Health Field, Occupational Risk Prevention Service Burgos Health Area 2012.
12. Deás Yero D, Gilart González F, Beira Fontaine L. Evaluation of the electromagnetic environment in rehabilitation rooms. MediSan. 2016; 20: 1013-1021.
13. Bassen H, Schaefer DJ, Zaremba L, Bushberg J, Ziskin M, Foster KR. Exposure of medical personnel to electromagnetic fields from open magnetic resonance imaging systems. Health Phys. 2005; 89: 684-689.
14. Barbosa N, Agulles-Pedrós L, Daza A, Lozano A. Biological effects and safety aspects of non-ionizing radiation in magnetic resonance. Rev Colomb Radiol. 2013; 24: 3790-3795.
15. Choi S, Cha W, Park J, Kim S, Kim W, Yoon X, et al. Extremely Low Frequency-Magnetic Field (ELF-MF) exposure characteristics among semiconductor workers. Int J Environ Res Public Health. 2018; 15: 642.
16. SSM's Scientific Council on Electromagnetic Fields, Recent Research on EMF and Health Risk - Thirteenth report from SSM's Scientific Council on Electromagnetic Fields 2019. SSM. 2020: 104.
17. Preciado Ramírez M, Luna Cano V. Basic Radiological Protection Measures. National Cancer Institute. Cancerology 2010; 5: 25-30.
18. Walwyn Salas G, González Mesa JE, Molina Pérez D, Ramos Machado D, López Bejerano GM, Fernández Gómez IM, et al. CPHR: 35 years of service to radiological protection, health and the environment. Nucleus. 2020; 6-13.
19. Carvajal de la Osa J, Pérez Almirall I. Castro Fernandez M. Analysis of the magnetic field in a hospital institution. Energy Engineering. 2018; 39: 176-185.
20. Díaz Roller Y, Rubia Lazo N, Carvajal de la Osa J, Castro Fernández M, Perez Almirall I. Analysis of electromagnetic interference generated by medical equipment in a neonatal intensive care unit. Ingeniería Energética. 2021; 42: 61-68.
21. Díaz Roller Y, Carvajal de la Osa J, Pérez Almirall I, Cepero Terrero S, Castro Fernández M. Analysis of the behavior of the magnetic field in computer laboratory areas. Energy Engineering. 2021; 42: 23-35.

22. Díaz Roller Y, Carvajal de la Osa J, Pérez Almirall I. Evaluation of exposure to extremely low frequency electromagnetic field in Cujae laboratoriesCCIA. 2018.
23. Ruz Ruiz M, Vázquez Serrano F, Cubero Atienza AJ, Salas Morera L, Jiménez Hornero JE, Arauzo Azofra A, et al. Human health effects of very low frequency electric and magnetic fields (ELF). 2010: 218.
24. Carpenter DO. Extremely low frequency electromagnetic fields and cancer: How source of funding affects results. Environmental Research. 2019; 178: 108688.