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EM PARCERIA COM: IEMS UNIASSELVI

Analysis of electromagnetic spectrum from radio stations in hospital units

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ABSTRACT

In intensive care units (ICUs), there is a diversity of electromedical equipment (EMS) sharing a short space even with other electronic devices. Although each piece of equipment has undergone electromagnetic compatibility tests, as well as the manuals guide which distances are necessary to avoid possible interference, some scenarios are not foreseen in practice, through these tests and currently hospitals share several sources of Radio Frequency (RF), such as smartphones, routers, among others. The objective of this article is to make measurements of possible scenarios that idealize a hospital environment such as an ICU, ICU, among others, at UNCISAL-AL, subjecting them to RF sources. In this work, we exclusively used radio stations, verifying if there are risks in the use of electromedical equipment and consequently of damage to hospital equipment, due to electromagnetic exposure above immunity in this equipment.

Keywords: Interference, Electromedical, Radio, Immunity.

INTRODUCTION

The increasing use of technologies, especially wireless communication and the diversity of electromagnetic disturbances that may be present in hospital units, can affect the operation of electromedical equipment. The integration of electronic devices, which include storage units, networks, communication interface has been growing in recent years. According to data from ANATEL's Certification and Homologation Management System (SGCH), between 2005 and 2012 the number of product homologations increased by 44.8%. For cellular terminal models approved by ANATEL, the increase was 862%. For restricted radiation transceiver models, which include Wi-Fi Bluetooth and RFID (Radio Frequency Identification) technology, the increase was greater than 1,000% (ANATEL SGCH, 2016).

The effects of electromagnetic interference (EMI) have turned on the warning signal of researchers, since if these interferences occur in electromedical equipment that supports a patient's life, they are responsible for monitoring vital parameters. In the scenario in which RF sources cause EMI, electromedical equipment must be safe and immune to these interferences (SUZY, 2001). Therefore, some scenarios should be analyzed to verify the electromagnetic stress of electromedical equipment.

Current hospital scenarios encompass environments that have a diversity of electrical and electronic equipment that emit electromagnetic waves through free space (air), at various frequencies,

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generating electric fields with different amplitudes. In hospital corridors, mobile devices are often used for communication (JAMILSON, 2018).

The guidelines and declaration of the manufacturer of the main electromedical equipment define that there must be a recommended separation distance between this equipment and the sources, depending on the maximum power of the transmitter and the frequency (IEC, 2010; IEC, 2014). However, in the analysis of electromagnetic interference from external sources, in urban environments the main sources of electromagnetic disturbances are the emissions of RBS (Base Radio Stations), used in cell phones, sound broadcasting stations (FM) and sound and image broadcasting (TV).

The construction of hospitals in the vicinity of RBS, as well as the various mobile technologies that coexist within hospitals, can contribute to electromagnetic interference that not only exceeds the immunity limits listed in the electromagnetic compatibility standards (EMC), but can also affect the operation of electromedical equipment.

The current operating scenarios of most hospitals foresee a large amount of electronic equipment that emits non-ionizing irradiation that has not been analyzed and can contribute significantly to the reduction of the limit of immunity and electromagnetic interference.

The objective of the research that generated this article was to measure possible scenarios that idealize a hospital environment such as an ICU, ICU, among others, making measurements of the electromagnetic spectrum radiated by radio stations, verifying if the measured levels offer risks in the use of hospital equipment.

METHODOLOGY

Electromedical equipment has low electromagnetic immunity, i.e., the maximum electric field that it withstands, without presenting breakdowns and/or non-conformities. Table 1 was constructed in order to associate the risk correlated with the type of equipment and the place of operation. Some electromedical devices have electromagnetic immunity that varies with frequency, as shown in Table 2.

Table 1. Electromagnetic immunity level of some electromedical equipment. (JAMILSON, 2018, p. 79)

PRODUCT	MODEL	BAND(MHz)	IMUNITY(V/m)
Anesthesia machine	DIXTAL/5020	80-2.500	10
Infusion pump	BRAUN/ Infusomat®	80-2.500	10
	BAXTER/ Colleague	26- 2.500	201
Pulmonary Ventilator	CAREFUSION / BE	80-2.500	10
	INTERMED / iX5	80-2.500	10
Pulse oximeter	MORIYA / M1000	80-2.500	3
	NELLCOR / OxiMax	80-2.500	3
	NONIN / 2500C	80-2.500	203

Multi-parameter monitor	INSTRAMED / INMAX	80-2.500	3
1 The main screen of the pump may dim or go blank at levels above 8 V/m. For uncontrolled EMF environments such as ground ambulances, the pump may stop infusing or alarm at a level of 15 V/m or greater. 2 ISO 9919:2005 requirements			

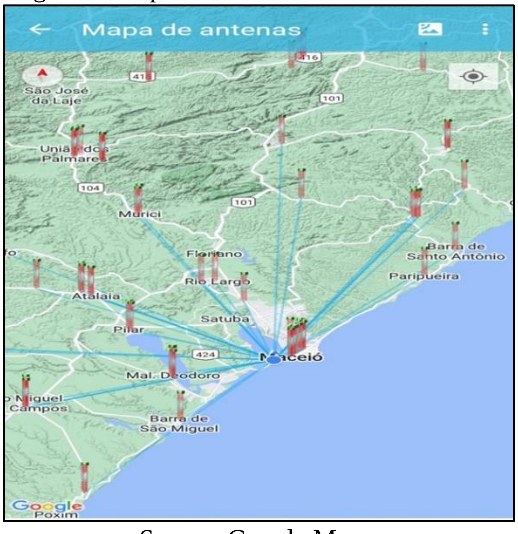
The guidelines and declaration of the manufacturer of the main electromedical equipment define that there must be a recommended separation distance between these equipment and the sources, depending on the maximum power of the transmitter and the frequency. However, in the analysis of electromagnetic interference from external sources, in urban environments, the main sources of electromagnetic disturbances are RBS, used in cell phones, sound broadcasting (FM) stations and sound and image broadcasting (TV). The powers and frequency range of these transmitters are shown in Table 2.

Table 2. Characteristics of Brazilian broadcasting services (ANATEL, 1998, 2001).

SERVICE	FREQUENCY	MAXIMUM TRANSMITTER POWER
TV VHF	54 – 88 MHz (VHF Baixa) 174 – 216 MHz (VHF Alta)	316 kW
FM RADIO	88 – 108 MHz	100 kW
TV UHF	470 – 800 MHz	1,600 kW
TV DIGITAL	470 – 668 MHz	80 kW
TV RELAY	VHF UHF	31.6 kW 160 kW

Initially, the main broadcasters, AM, FM and TV stations were listed in the city of Maceió-AL. In fig.1, a screen can be seen showing how the search for broadcasters was carried out with the Google platform search tool.

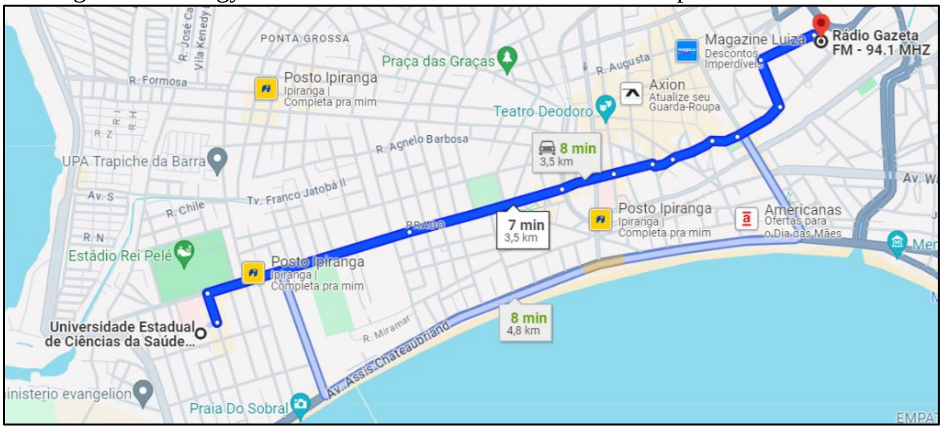
Figure 1. Map of distribution of radio stations.



Source: Google Maps.

Parameters such as operating frequency, maximum probable transmitter power, and direct view distance (straight line) to UNCISAL-AL were identified. Fig.2 shows how the tool was used to calculate the distance to the reference point, i.e., the UNCISAL-AL. The objective of identifying the distance to UNCISAL-AL is to identify, if a hospital unit were built at this reference point, what would be the electromagnetic field perceived by any electromedical equipment installed in this location (receivers). Measurements were initially performed in an open environment.

Figure 2. Strategy for the calculation of each broadcaster up to UNCISAL-AL.



Source: Google Maps.

Before making the measurements, the theoretical (probable) electric fields, perceived at UNCISAL-AL, by the sources identified in the research were calculated. The characteristics of Brazilian broadcasting services were consulted in (JAMILSON, 2018, pg. 40). And the estimate of the level of disturbance caused by the source (electromagnetic field intensity) was calculated through (JAMILSON, 2018, pg. 73):

$$E = \frac{6\sqrt{P}}{d} \qquad (1)$$

Where:

E is the electromagnetic field strength [V/m]

P is the maximum power [W],

d is the minimum separation between source and receiver [m].

Then, the values were measured through a spectrum analyzer, from the manufacturer *RF Explorer* 2.45 GHz, a 2.0 dBi gain receiving antenna that showed on its screen the level of the power captured by the receiver antenna and dBm and the frequency of the emitting source. By entering the data obtained in eq. 2 (JULIO, 2016, pg. 236), the value of the electromagnetic field is obtained.

$$|E| = \left(\frac{P_{rx}.480\pi^2}{G.\lambda^2}\right)^{\frac{1}{2}} \qquad (2)$$

Where

|E| electromagnetic field module [V/m]

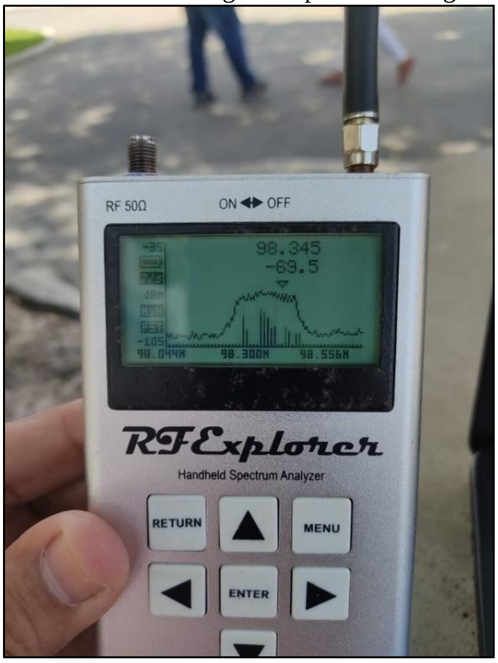
$\boldsymbol{P_{rx}}$ is the received power [W];

G is the dimensionless gain of the receiving antenna.

λ is station wavelength(RF source) [m]

In fig.3, an extract of one of the measurements can be seen on the screen of the equipment. In the equipment, the frequency bandwidth that contained the frequency of the desired transmitter was selected and the power level in dBm was displayed on the screen.

Figure 3. Measurement of the electromagnetic spectrum using the spectrum analyzer.



Source: The authors.

RESULTS AND DISCUSSIONS

The calculated and measured data, as well as the difference in percentage, can be seen in Table 3.

Table 3. Theoretical result is measured in an external environment. [3]Mean with standard deviation.

Radio/Frequency Name	Theoretical electric field(V/m)	Measured electric field (V/m) External Environment	Percentage Difference (%)
Radio Gazeta FM-94.1MHz	0,0558	0,0003	60,00
Rádio Farol FM-90,1MHz	0,3530	0,0001	87,00
Rádio 96 FM-96,5MHz	0,3810	$5{,}0.10^{-5}$	92,60
Rádio Mix FM-98,3MHz	0,6100	0,0001	33,00
Radio Jovem Pan FM-100.7MHz	0,6100	$2{,}0.10^{-5}$	10,00
Radio Transamerica FM-102.7MHz	0,6100	$8{,}0.10^{-5}$	14,30
Radio Pajuçara FM-103.7MHz	0,6800	0,00071	99,89
Rádio CBN FM-104,5MHz	0,3720	$7{,}2.10^{-5}$	75,00
FM-107.7MHz Educational Radio	0,4362	$1{,}8.10^{-5}$	51,10
Rádio Nova Brasil FM-106.5MHz	0,4170	0,00123	78,00
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The measurement results are far from those measured. The justifications are due to the fact that the theoretical levels calculated according to eq. (1), do not take into account the attenuation of the electric field at obstacles that exist between the broadcasters and the external reference point, the UNCISAL-AL, other dispersion factors, the power of the transmitter which may be lower than that listed in table 2, as well as the power level of the station being variable according to the time of day, affecting the measurement result. In the last column, you can see the percentage difference between the expected theoretical value and the measured actual level.

Then, the measurements were carried out in a closed environment, on the premises of UNCISAL-AL, a room surrounded by walls, and the measured levels were compared with those of the external environment. The data can be seen in Table 4.

Table 4. Comparison between outdoor and indoor measurements. [4]Mean with standard deviation.

Radio/Frequency Name	Measured electric field (V/m) External Environment	Measured electric field (V/m) Indoor Environment	Percentage Reduction (%)
Radio Gazeta FM- 94.1MHz	0,0003	0,00012	60,00
Rádio Farol FM-90,1MHz	0,0001	$1{,}3.10^{-5}$	87,00
Rádio 96 FM-96,5MHz	5.10^{-5}	$3{,}7.10^{-6}$	92,60
Rádio Mix FM-98,3MHz	0,0001	$6{,}7.10^{-5}$	33,00
Radio Jovem Pan FM-100.7MHz	2.10^{-5}	$1{,}8.10^{-5}$	10,00
Radio Transamerica FM-102.7MHz	8.10^{-5}	$7{,}0.10^{-5}$	91,25
Radio Pajuçara FM-103.7MHz	0,00071	0,00015	78,87

Rádio CBN FM-104,5MHz	$7,2.10^{-5}$	$1,8.10^{-5}$	75,00
FM-107.7MHz Educational Radio	$1,8.10^{-5}$	$8,8.10^{-6}$	51,11
Rádio Nova Brasil FM-106.5MHz	0,00123	0,00027	78,05
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The measurements in the external environment were carried out in an environment free of direct attenuating surfaces such as walls and obstacles. And the measurements in the internal environment were carried out within the premises of UNCISAL-AL, in an environment that has walls, in which there is an expectation of an electromagnetic field with lower intensity, as can be seen in table 4. This is due to the dielectric factor caused by the walls of the building, but this attenuation was significant in percentage terms.

The third measurement was carried out in the vicinity of the stations. The measurements were carried out in direct view at the stations about a maximum of 10.0 m from the radios. The levels can be seen in Table 5.

Table 5. Measurements in the vicinity of radio stations.

Radio/Frequency Name	**Measured electric field (V/m) External Environment**
Radio Gazeta FM- 94.1MHz	0,010
Rádio Farol FM-90,1MHz	0,002
Rádio 96 FM-96,5MHz	0,006
Rádio Mix FM-98,3MHz	0,010
Radio Jovem Pan FM-100.7MHz	0,010
Radio Transamerica FM-102.7MHz	0,010
Radio Pajuçara FM-103.7MHz	0,005
Rádio CBN FM-104,5MHz	0,00001
FM-107.7MHz Educational Radio	0,0008
Rádio Nova Brasil FM-106.5MHz	0,0002

The electric field levels measured in the vicinity of the radio stations, although they are much higher when compared to the levels observed in the environments; external (tab.2) and internal (tab.3) are irrelevant when compared with the lower immunity presented in tab.1, i.e., 3V/m. Therefore, there is no risk of using electromedical equipment, even if the hospital units were built in the vicinity of radio stations.

CONCLUSIONS

The measurement results presented in the work certify that in fact the electric field radiated by the radio stations does not pose a risk for eventual construction of hospital units, relatively distant or even close to radio stations, considering that the electric field measured in the scenarios presented is much lower than the immunities of the main electromedical equipment listed in table 1. However, it is necessary, which is not often observed, for a spectral analysis before and after construction in hospital units. It is worth noting that analyses involving other RF sources, such as smartphones, tablets, Wi-Fi routers, among others, were not the object of this research and consequently could eventually have higher measurement levels than those observed in this research.

ACKNOWLEDGMENT

Thanks should be made to UNCISAL-AL, which from the Scientific Initiation program, in the modality, PIBIC/FAPEAL existing in the institution and funded by FAPEAL (Foundation for Research Support of the State of Alagoas), allowed the development and execution of this research.

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