PANORAMA OF DIAGNOSTIC RADIOLOGY IN BRAZIL

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I. Introduction

The history of X-ray imaging in Brazil has started in 1896, when Dr. Adolpho Carlos Lindenberg, physician, published the first thesis about radiology in Brazil, which cover's translation is [1]:

"DISSERTATION
MEDICAL PHYSICS CHAIR
ABOUT X-RAY
IN THE POINT OF VIEW OF MEDICAL-SURGICAL
PROPOSITION
Three about each one of the chairs of the medical and surgical sciences
THESIS
PRESENTED TO
Faculty of Medicine of Rio de Janeiro
In 5th of November of 1896
By
ADOLPHO CARLOS LINDENBERG
Natural from the State of Rio de Janeiro
IN ORDER TO OBTAIN THE DEGREE OF DOCTOR IN MEDICINE".

The Medical Physics Chair, as mentioned in the thesis cover, was established in 1832 by the law of 3rd of October of 1832, by the Emperor D. Pedro II. This law regulated the Faculties of Medicine in Brazil and created 14 permanent Chairs, where Medical Physics was the first Chair [2].

In 1897, Dr. José Carlos Ferreira Pires, physician, bought the first X-ray machine in Brazil and installed in the city of Formiga, Minas Gerais. The first public demonstration of a radiography was in 1898, a foreign body in the hand of a Minister. This X-ray machine is in the International Museum of Surgical Science, in Chicago, Illinois, USA [3].

An important contribution from Brazil to the diagnostic radiology worldwide was in 1936, when a Brazilian radiologist, Dr. Manoel Dias de Abreu, developed a revolutionary method for mass tuberculosis screening. It was miniatures of chest X-ray (about 50 to 100 mm size), named by him as Roentgengraphy. In 1939, the 1st National Congress of Tuberculosis changed the name of this technique to Abreugraphy, in his honor [3].

Diagnostic radiology in Brazil has started right after the X-ray discovery, despite that, the development of Medical Physics in this area had the official first steps in 1977 [4]. Nowadays, the number of Clinically Qualified Medical Physicists (CQMP) in diagnostic radiology is yet very small all over the country.

II. Current Status

Brazil is the largest Latin American country in terms of territory and it is divided in five regions: Midwest, Northeast, North, Southeast and South (Fig. 1). The total population estimative in July of 2018 is 208,494,900, according to IBGE (Brazilian Institute of Geography and Statistics). Table 1 shows Brazil's population and territory distribution in Brazil. The most populous region is the Southeast and the largest in territory is the North, corresponding to 45% of the national area [5,6].

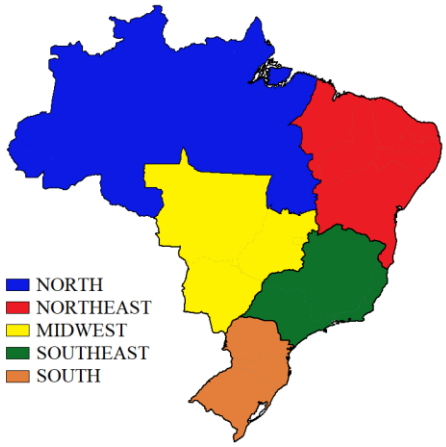

Fig. 1 Map of Brazil divided by regions.

Table 1. Population and territory distribution in Brazil.

	Area (km²)	%	Population	%
Total	8,515,759	100%	208,494,900	100%
North	3,853,841	45%	18,182,253	9%
Northeast	1,554,291	18%	56,760,780	27%
Midwest	1.606.234	19%	16,085,885	8%
Southeast	924,609	11%	87,711,946	42%
South	576,784	7%	29,754,036	14%

The National Cancer Institute estimates, for the year of 2018, more than 630,000 new cases of malignant neoplasms

[7]. Besides the several diseases that relies on X-ray imaging to be detected, this data demonstrates the importance of excellence in diagnosis and cancer therapy in Brazil, which makes the CQMP increasingly necessary all over the country.

According to the National Registry of Health Facilities (CNES – Cadastro Nacional de Estabelecimentos de Saúde, in Portuguese), there are 137,074 diagnostic imaging equipment available in the country, including nuclear medicine. The data from CNES states that 94% of the equipment is operating and less than 30% is disposable to the public healthcare. Furthermore, the number of high complexity imaging systems is very small for the entire country. For example, there are less than 5,000 Computed Tomography (CT) scans and only 2,034 to assist the public healthcare [8].

Table 2 shows the number of equipment per imaging modality. The reason why the operating equipment is lower than to the total number is not described in the CNES database. A probable justification is the health facilities' insufficient funds for proper equipment maintenance. Some hospitals and/or clinics, especially in the public healthcare, remain with a broken equipment for years. In these cases, the machine usually finishes its lifetime without the possibility of repairing.

Table 3 shows the number of diagnostic imaging equipment per 100,000 inhabitants for each region in Brazil. Despite the elevated number of equipment for a low-income country, due to the large population and territorial extension, the diagnostic imaging resources are insufficient. Furthermore, film-screen radiology is still largely used in Brazil. According to CNES, there are 2,721 film processor systems exclusively dedicated to mammography and the public healthcare possess 2,065 of these systems.

The first program of Bachelor´s degree in Medical Physics in Brazil appear in the year of 2000 and currently there are 11 programs [9].

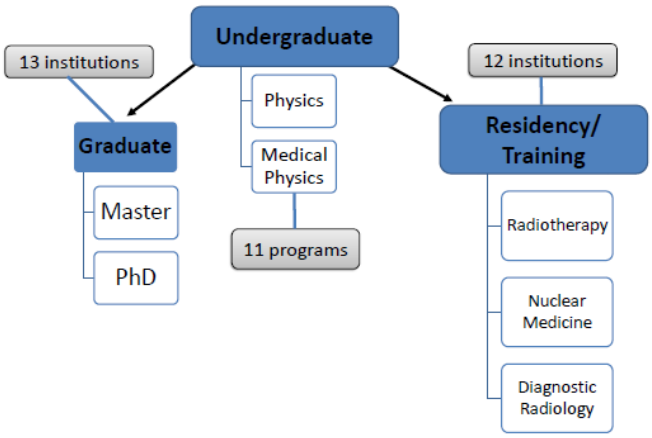

Fig. 2 Diagram of CQMP education in Brazil.

Residency programs in diagnostic radiology have started in 2013. Brazilian law requires they have a minimum of 1153 hours of didactical instruction in classroom and at least 4608 hours of practical training. There are 12 institutions with Residency programs and they offer approximately 34 positions, nine of them are in diagnostic radiology.

The low number of diagnostic imaging equipment, especially considering the population and territory extension, combined to the few clinical training programs, are a big challenge to increase the number of CQMP in diagnostic radiology.

Table 2. Number of equipment in Brazil, divided by imaging modality.

Image Modality	Total	Operating	Public Healthcare
PET/CT	72	71	38
MAMMOGRAPHY W. STEREOTACTIC SYSTEM	913	869	355
MAMMOGRAPHY (FILM-SCREEN/DIGITAL)	5,505	2,409	1,130
INTERVENTIONAL RADIOLOGY	906	875	335
GAMMA CAMARA	976	936	356
MAGNETIC RESSONANCE	2,544	2,475	961
BONE DENSITOMETRY	2,325	2,279	808
FLUOROSCOPY SYSTEMS	1,723	1,541	556
COMPUTED TOMOGRAPHY	4,735	4,578	2,034
X-RAY (CONVENTIONAL AND PORTABLE)	24,267	23,092	9,964
ULTRASSOUND	40,420	38,871	12,957
DENTAL X-RAY	53,183	49,068	7,346
TOTAL	137,074	129,482	37,970

III. MEDICAL PHYSICS IN DIAGNOSTIC RADIOLOGY

The education for the CQMP in diagnostic radiology follows the steps described in the diagram below (Fig. 2).

IV. PROFESSIONAL REGULATION

The profession of Physicist and Medical Physicist was not regulated up to 10th of July of 2018. This process started in 11th of May of 2005, when a Senator proposed the bill to the professional regulation request by a group of physicists. The legal process lasted 13 years with large interaction of the Brazilian Society of Physics and the Brazilian Association of Medical Physics. This is a important step to the Medical Physics in Brazil development.

V. CURRENT CHALLENGES

Diagnostic radiology in Brazil is expanding and developing very fast. Figure 3 shows the increase of diagnostic imaging equipment in the last 10 years. In 2008, there was 82,669 equipment in Brazil and 38 CQMP certified in diagnostic radiology by the Brazilian Association of Medical Physics. Nowadays there are 137,074 equipment and 91 CQMP certified.

Table 3. Number of equipment each region in Brazil per 100,000 inhabitants.

	NORTH	NORTHEAST	SOUTHEAST	SOUTH	MIDWEST
PET/CT	1,1	2,6	3,9	5,0	3,1
INTERVENTIONAL RADIOLOGY	28,0	27,8	51,5	55,1	50,4
FLUOROCOPY	29,1	33,5	121,0	104,9	66,5
GAMMA CAMARA	37,9	30,1	52,4	51,8	51,0
BONE DENSITY X-RAY	66,0	79,1	134,2	126,0	126,8
MAGNETIC RESSONANCE	83,0	75,2	144,1	154,9	149,8
FILM PROCESSOR FOR MAMMOGRAPHY	100,1	121,2	126,9	159,6	121,2
COMPUTED TOMOGRAPHY	155,6	150,8	260,1	279,3	300,9
MAMMOGRAPHY	185,9	222,9	307,6	302,5	302,1
X-RAY	738,1	806,5	1318,3	1197,1	1272,5
DENTAL X-RAY	1158,3	1389,7	3060,6	3055,0	1951,4
ULTRASSOUND	1246,3	1561,1	2039,7	2215,2	2027,9
Total	3809,8	4488,0	7589,7	7686,0	6399,4

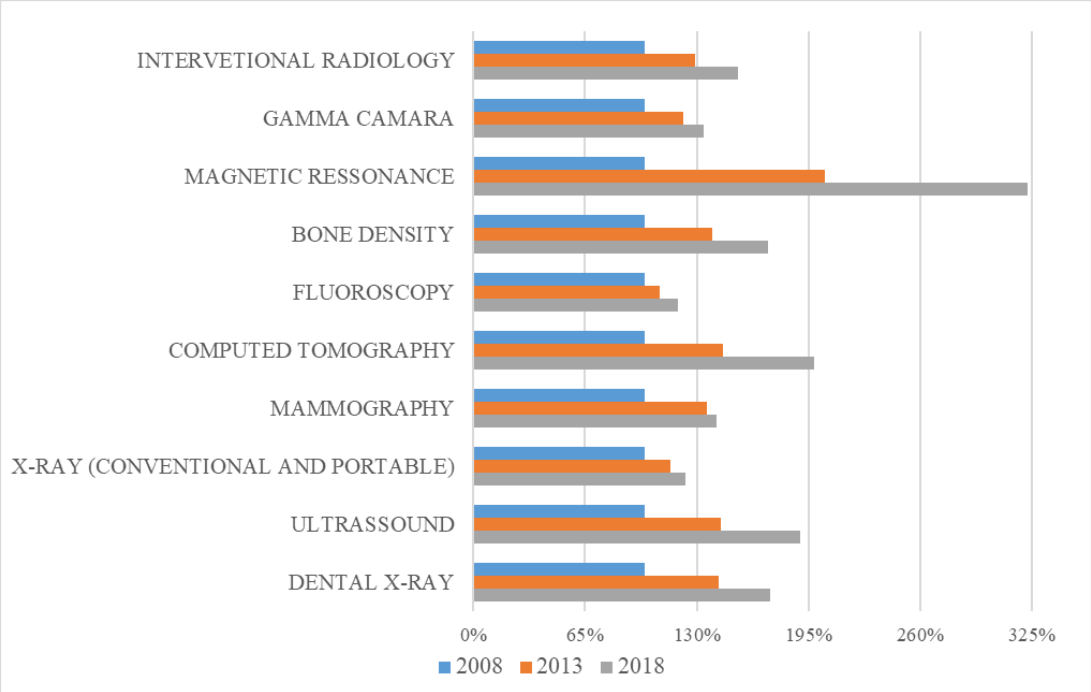

Fig. 3 Increasing of diagnostic imaging equipment in Brazil in 10 years.

Although the recent regulation of the profession, there is no national Council yet. Consequently, there is no database about the number of professionals working as CQMP. In general, Medical Physicists in diagnostic radiology work at private companies that perform quality control and radiation survey for hospitals and clinics, as requested by law since 1998. However, there are other professions performing these activities, such as radiology technicians and technologists, because of the practice directives absence.

Another issue is the lack of job positions at hospitals and clinics for CQMP in diagnostic radiology. Since 2012 there were 55 new positions created in Federal University Hospitals [10]. Nevertheless, most of the private hospitals does not have the knowledge of the CQMP roles and responsibilities, thus there are not many job positions for it. In general, when a CQMP is hired, he/she also assumes the responsibilities of Radiation Protection Officer.

VI. WAY FORWARD

Brazil has a promising perspective for the development of the Medical Physics and medical imaging. The achievements chronology (Fig. 4) indicates the evolution towards to the goal of increasing the Medical Physics workforce in Brazil and possibly to contribute to the whole Latin America. There were 1,256 Medical Physicists in Latin America and Caribbean in 2017 [11], mostly in radiotherapy.

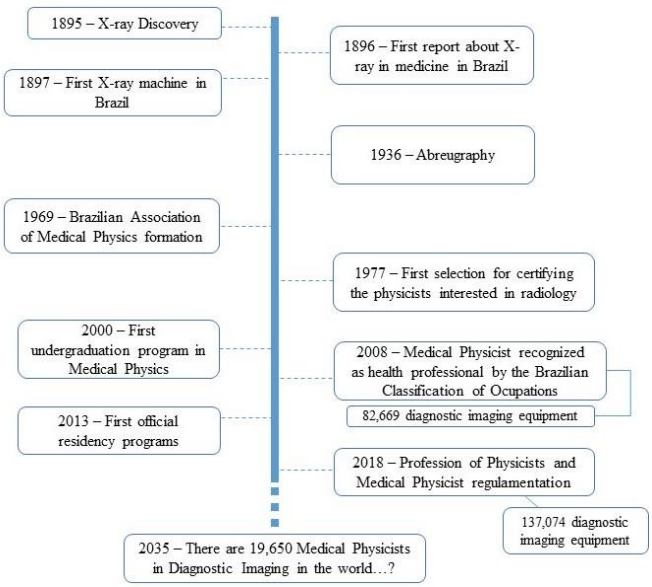

Fig. 4 Chronology of the diagnostic imaging and Medical Physics in Brazil

As the medical imaging technology in Brazil is expanding, the high technologies as Positron Emission Tomography with Magnetic Resonance Imaging (PET/MRI), hybrid operating rooms of interventional radiology, dual energy CT scans, among others are already a reality in the country. The importance of having trained physicists to be CQMP in diagnostic radiology is rising together with this technology expansion. The CQMP needs to be inside the hospitals and clinics to support an appropriate Quality Assurance Program and to guarantee the radiation safety and proper diagnosis for each patient.

Conflict of Interest

The authors declare that they have no conflict of interest.

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