



Evaluating the Curriculum for B.S. of Radiologic Technology in Iran: An International Comparative Study

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ABSTRACT

Introduction: The present study aimed to conduct a comprehensive study in order to comparatively examine the curriculum for B.S. of Radiologic Technology in Iran and a number of selected countries and introduce the appropriate model for Iran. Methods: Data were collected using the document analysis technique. Using the Internet, the documents related to this field were collected from the curriculum of major world universities, categorized, and analyzed. Results: The findings showed that the duration of study differs across countries. For instance, it is 3 years in most European countries and 4 years in Iran. The title of course is Radiology Technology in Iran, USA, and Saudi Arabia, while it is Diagnostic Radiography in most European countries. The modalities of nuclear medicine radiography and diagnostic ultrasound are also included in the curriculum of the three-year program in British universities. In Iran, nuclear medicine and radiotherapy are taught as a separate course and the ultrasound course which is included in the program is not efficient. Conclusion: The Iranian curriculum does not significantly differ from those of other countries. However, it is necessary to continuously integrate courses, introduce digital image processing subjects, and employ radiography simulation systems in order to enhance the students' learning in the Iranian curriculum of Radiologic Technology.

Keywords: Comparative Study, Curriculum, Diagnostic Radiography, Continuous Integration, Iran

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INTRODUCTION

Radiologic Technology is a growing paramedical major which plays a significant role in the process of diagnosis and treating diseases and contributes to human health [1]. With the rapid expansion of technology in the past two decades, the number and complexity of medical radiography demands remarkably increase at all levels of patient care [1, 2]. It is estimated that over 10 millions radiologic examinations are performed daily on over the world [1, 3, 4]. Moreover, from 1990 to 2006, the number of radiologic examinations increased at the rate of 2.2 times the rate of population growth around the world, which is a considerable increase [1]. The major aim of this program is providing the foundation for acquiring educational experiences and use of novel devices and

technologies in the field of medical radiography [5]. New techniques and devices are introduced to the market annually. Therefore, students of Radiology Technology must learn how to correctly use these devices in the diagnosis of diseases in addition to learning the noted techniques [6]. The correct instruction of radiologic technology is necessary for medical students as well as technologist and radiologists [2]. Educational issues and aims are similar in most universities. Nevertheless, methods and planning of the educational system differ in terms of the content of curriculum, teaching methods, design of the program, evaluation methods, and available human force. These factors are somewhat related to the traditions and cultures of different societies as well [7]. Considering the advances and changes in healthcare standards around the world, new ideas and methods are required for updating curricula and making them more efficient. To this end, the easiest way is conducting

comparative studies on curricula [8]. The periodic revising of curricula in all science majors is a basic principle of the educational process, thereby improving the quality of teaching in all credible universities and higher education centers around the world [9, 10]. Various studies have so far been conducted, explaining the role of radiology in the curricula of schools of medicine and focusing on the improvement of these curricula [7]. Therefore, the present study aimed to conduct a comprehensive and comparative study of the curriculum for B.S. of Radiologic Technology in Iranian universities and those of some selected countries in order to provide practical suggestions for improving the status of this curriculum in Iran.

MATERIALS AND METHODS

The present study was a review study, which comparatively examined the curricula of Radiologic Technology in the universities of Iran and 14 others countries. In order to collect data, researchers used the document analysis technique. Documents related to this major were collected from the curricula of major world universities using the Internet, categorized, and analyzed. The selected universities were among the top-ranking universities in the world in terms of scientific status and had presented

their full curriculum on their respective websites. In order to analyze and compare these curricula, a framework of 9 items (general design of curriculum, presentation of the program, title of the program, duration of the program, teaching methods, diversity of credits, type of program, comprehensive exam, and the number of semesters) was provided. Based on these parameters, all theoretical and practical specialized courses, fundamental courses, general courses, and apprenticeship credits were evaluated.

RESULTS

General Design of the Curriculum

In Iran, the curriculum for B.S. of Radiologic Technology comprises three subjects: general specifications of the program, specifications of the educational program, and course topics and evaluation methods. Curricula were extracted from credible university websites, and the results are shown in Table 1 for facilitating the comparative study. The total number of credits for passing the program for B.S. of Radiologic Technology is 130, including 22 general credits, 31 fundamental credits, 61 specialized credits, and 16 apprenticeship credits. The duration of this program is four years and 8 academic semesters.

Table 1. Undergraduate radiologic technology program (courses, credits)

Course Code	Course	Credit NUM.	Hour			Prerequisite	Semester
			Theoretical	Practical	Total		
01	<i>Introduction to Modern Information Technology</i>	2	17	34	51	-	First
02	Anatomy 1	2	17	34	51	-	First
03	Physiology	2	17	34	51	-	First
04	Persian Literature	3	51	-	51	-	First
05	English Language (prerequisite)	2	34	-	34	-	First
06	Physics (prerequisite)	2	34	-	34	-	First
07	Statistics	1	17	-	17	-	First
08	General Health	1	17	-	17	-	First
09	Islamic Thought 1	2	34	-	34	-	First
10	Physical Education 1	1	-	34	34	-	First
11	Life Skills	-	-	-	-	-	First
12	Population and Family Knowledge	2	34	-	34	-	First
13	General Physics	3	34	17	51	06	Second
14	General Mathematics	2	34	-	34	-	Second
15	General English Language	3	51	-	51	05	Second
16	Anatomy 2	2	34	-	34	-	Second
17	Registration and Display of Medical Images	2	34	-	34	-	Second
18	Radiographic Procedures 1	3	51	-	51	02	Second

19	Radiation Physics	3	51	-	51	-	Second
20	Apprenticeship 1	2	-	102	102	-	Second
21	Anatomy 2	2	34	-	34	-	Third
22	General Pathology	2	34	-	34	03	Third
23	Computer Applications in Medical Imaging	2	17	34	51	01	Third
24	Medical Terminology in Radiology	1	17	-	17	-	Third
25	Physics of Diagnostic Radiology	3	51	-	51	19	Third
26	Radiographic Procedures 2	3	51	-	51	16	Third
27	Technical Language	2	34	-	34	15	Third
28	Islamic Thought 2	2	34	-	34	09	Third
29	Physical Education 2	1	17	-	17	10	Third
30	Apprenticeship 2	2	-	102	102	-	Third
31	Radiographic procedures 3	2	34	-	34	21	Fourth
32	Cell Biology	2	34	-	34	-	Fourth
33	Pathology	2	34	-	34	22	Fourth
34	Sectional Anatomy	3	51	-	51	21	Fourth
35	Ionizing Radiation Dosimetry	2	34	-	34	19	Fourth
36	Basic Maintenance and Repairment of Radiology Equipment	2	34	-	34	25	Fourth
37	Patient Care in Medical Imaging	2	17	34	51	03	Fourth
38	Apprenticeship 3	2	-	102	102	-	Fourth
39	Ultrasound in Medical Imaging	3	51	-	51	-	Fourth
40	Radiobiology	2	34	-	34	19-32	Fifth
41	Islamic Ethics	2	34	-	34	-	Fifth
42	Specific radiographic procedures	2	34	-	34	-	Fifth
43	Evaluation of Medical Images 1	2	34	-	34	33	Fifth
44	Physical Principles of CT Scan	2	34	-	34	25	Fifth
45	Protection Against Ionizing Radiation	2	34	-	34	35	Fifth
46	Islamic History and Civilization	2	34	-	34	-	Fifth
47	Seminar 1	1	-	34	34	-	Fifth
48	Physical Principles of MRI	2	34	-	34	-	Fifth
49	Professional Ethics	2	17	34	51	-	Fifth
51	Introduction to the Values of the Sacred Defense	-	-	-	-	-	Fifth
51	Apprenticeship 4	2	-	102	102	-	Fifth
52	Quality Assurance and Quality Control in Radiology	3	34	34	68	44-48	Sixth
53	Techniques of CT Scan	2	34	-	34	34-44	Sixth
54	Seminar 2	1	-	34	34	-	Sixth
55	Introduction to Contrast Media	2	34	-	34	-	Sixth
56	Introduction to Islamic Texts	2	34	-	34	-	Sixth
57	Hospital Management and Organizational Behavior	2	34	-	34	-	Sixth
58	Islamic Revolution of Iran	2	34	-	34	-	Sixth
59	Culture and Civilization of Islam and Iran	2	34	-	34	-	Sixth
60	MRI Techniques	2	34	-	34	34-48	Sixth
61	Evaluation of Medical Images 2	2	34	-	34	34-43	Sixth
62	Apprenticeship in the Field (CT Scan)	4	-	204	204	53	Seventh
63	Apprenticeship in the Field (Special radiography)	4	-	204	204	42	Seventh
64	Apprenticeship in the Field (MRI)	4	-	204	204	60	Eighth
65	Apprenticeship in the Field (Sonography)	4	-	204	204	61	Eighth

Presentation of the Program

This program is presented as a full-time program in most countries, in two portions of academic and hospital internship. In the majority of countries, the title of the program is selected based on the type of education program (Table 2). The duration of program differs in different universities and countries, generally ranging from 3 to 4 years, independent of the type of program (Table 3).

Table 2. Radiologic Technology Program Name in Different Countries.

University	Program Name
Iran	Radiology Technology
South Australia (Australia)	Medical Radiation Science (Medical Imaging)
Sidney (Australia)	Diagnostic Radiography/Medical Imaging
Monash (Australia)	Radiography/Medical Imaging
Okayama (Japan)	Radiological Technology
Hong Kong (China)	Radiography
Singapore (Singapore)	Diagnostic Radiography/Imaging
King Saud (Saudi Arabia)	Radiologic Technology
Holy Angel (Philippines)	Radiologic Technology
Durban (South Africa)	Diagnostic Radiography
Exeter (England)	Medical Imaging/Diagnostic Radiography
Bournemouth (England)	Diagnostic Radiography
Metropolitan (Denmark)	Radiological Diagnostic Imaging
Johns Hopkins (USA)	Radiography
Hartford (USA)	Radiologic Technology (Medical Imaging)
Malta (Malta)	Radiography
Bologna (Italy)	Imaging and Radiotherapy Techniques
McMaster (Canada)	Medical Radiation Science (Technologist)

Table 3. The Length of the Degree Course in Radiologic Technology at Various Universities in the World

University - Country	The Length of the Degree Course (year)	Method of Educating Diagnostic and Therapeutic Radiology Topics
Bournemouth (Britain)	3	Separate
Metropolitan (Denmark)	3½	Combined
Scotland	4	Separate
Czech Republic	3	Combined

Italy	3	Combined
Monash	4	Separate
Liverpool	3	Separate
London	3	Separate
Leeds	3	Separate
Bradford	3	Separate
Cumbria	3	Separate
Derby	3	Separate
Hertfordshire (England)	3	Separate
Okayama (Japan)	4	Combined
Johns Hopkins (USA)	1½	Combined
Notre Dame (USA)	1½	Combined
Bologna (Italy)	3	Combined
Parma (Italy)	3	Combined
Dalhousie (Canada)	4	Combined
McMaster (Canada)	4	Combined
Netherlands	4	Combined
Japan	4*	Combined
Iran	4	Separate
King Saud (Saudi Arabia)	4	Combined
Singapore	3-4	Separate
Philippines	4	Separate
Durban Technology (South Africa)	4	Separate
Jordan	4	Diagnostic and Therapeutic Radiology Topics are educated in a combination.
Hong Kong (China)	4	Combined
Sidney	4	Separate
South Australia	4	Separate

* There is also a non-academic educational system for radiology, with duration of 3 years in Japan.

Teaching Methods and Diversity of Courses:

Teaching methods include lectures, seminars, group work, workshops, practical laboratory and hospital sessions, evidence-based problem-solving, discussions, using logbooks, simulation and educational anthropomorphic phantoms, group and individual projects, and direct studies in various universities. In general, course credits can be categorized into three categories of fundamental sciences and mathematics, general education (humanities, arts, and social sciences),

and specialized sciences related to radiography (Tables 4-6).

Table 4. Variation of Courses in Basic Sciences and Mathematics.

University		Physiology	Anatomy	Chemistry	Physics	Mathematics	Biology	Pathology
Basic Sciences and Mathematics								
Iran	Lorestan Medical Sciences	✓	✓	×	✓	✓	✓	✓
USA	Hartford	✓	✓	✓	×	✓	✓	✓
	Notre Dame	✓	✓	✓	✓	✓	✓	✓
England	London	✓	✓	×	×	×	×	✓
	Bournemouth	✓	✓	×	✓	×	×	✓
	Liverpool	✓	✓	×	✓	×	×	✓
	Hertfordshire	✓	✓	×	×	×	×	✓
	Bradford	✓	✓	×	×	×	×	✓
	Exeter	✓	✓	×	✓	✓	×	✓
Canada	McMaster	✓	✓	×	✓	✓	✓	✓
	Dalhousie	✓	✓	×	✓	×	×	✓
Italy	Parma	✓	✓	×	✓	×	✓	✓
	Bologna	✓	✓	×	✓	✓	✓	✓
Singapore	Singapore Institute	✓	✓	×	×	×	✓	✓
	Parkway college	✓	✓	×	×	×	×	✓
Australia	Sidney	✓	✓	✓	✓	✓	✓	✓
	Monash	✓	✓	✓	✓	×	✓	✓
	South Australia	✓	✓	×	✓	✓	×	✓
South Africa	Durban Technology	✓	✓	✓	✓	×	×	✓
Philippine	Holy Angel	✓	✓	×	✓	✓	×	✓
Saudi Arabia	King Saud	✓	✓	✓	✓	✓	×	✓
Japan	Okayama	✓	✓	×	✓	✓	✓	✓
	Kyorin	✓	✓	✓	✓	✓	✓	✓
China	Hong Kong	✓	✓	✓	✓	✓	✓	✓
Denmark	Metropolitan	✓	✓	×	×	×	✓	✓
Malta	Malta	✓	✓	×	×	×	×	✓

Table 5. Variation of Courses in General Education.

University		Psychology Principles	Professional Ethics	First Aid	Management and Rules	Patient Care	English Language	Computer sciences
General Education								
Iran	Lorestan Medical Sciences	×	✓	×	✓	✓	✓	✓
USA	Hartford	✓	×	×	×	✓	×	✓
	Notre Dame and Johns Hopkins	✓	✓	×	✓	✓	×	✓
England	London	✓	✓	×	✓	✓	×	✓
	Cumbria	✓	✓	×	×	✓	×	✓
	Bournemouth	✓	✓	×	✓	✓	×	✓
	Liverpool	✓	✓	×	✓	✓	×	✓
	Hertfordshire	✓	✓	×	✓	✓	×	✓
	Bradford	✓	✓	×	✓	✓	×	✓
Canada	Exeter	✓	✓	×	✓	✓	×	✓
	McMaster	✓	✓	×	✓	✓	×	✓
	Dalhousie	×	✓	×	✓	✓	×	×
Italy	Parma	✓	✓	×	✓	✓	✓	✓

	Bologna	✓	✓	✓	✓	✓	✓	✓
Singapore	Singapore Institute	✓	✓	✗	✓	✓	✗	✓
	Parkway college	✓	✓	✗	✓	✓	✗	✓
Australia	Sidney	✓	✓	✗	✓	✓	✗	✓
	Monash	✓	✓	✗	✓	✓	✗	✓
	South Australia	✓	✓	✗	✗	✓	✗	✓
South Africa	Durban Technology	✓	✓	✗	✓	✓	✗	✗
Philippine	Holy Angel	✓	✓	✗	✓	✓	✓	✓
Saudi Arabia	King Saud	✗	✓	✓	✗	✓	✓	✓
Japan	Okayama	✓	✓	✗	✓	✓	✗	✓
	Kyorin	✓	✓	✗	✓	✓	✓	✓
China	Hong Kong	✓	✓	✗	✓	✓	✓	✓
Denmark	Metropolitan	✓	✓	✓	✓	✓	✗	✓
Malta	Malta	✓	✓	✓	✓	✓	✗	✓

Table 6. Variation of Courses in Specialized sciences.

University Specialized sciences		Radiation Physics	Radiobiology and Dosimetry	CT Scan Physics and Techniques	MRI Physics and Techniques	Sonography Physics and Techniques	Nuclear Medicine Physics and Techniques	Radiotherapy Physics and Techniques	Radiography Techniques
Iran	Lorestan Medical Sciences	✓	✓	✓	✓	✓	✗	✗	✓
USA	Hartford	✓	✓	✓	✓	✓	✓	✗	✓
	Notre Dame and Johns Hopkins	✓	✓	✓	✓	✓	✓	✓	✓
England	London	✓	✓	✓	✓	✓	✓	✗	✓
	Cumbria	✓	✓	✓	✓	✓	✓	✗	✓
	Bournemouth	✓	✓	✓	✓	✓	✓	✗	✓
	Liverpool	✓	✓	✓	✓	✓	✓	✗	✓
	Hertfordshire	✓	✓	✓	✓	✓	✓	✗	✓
	Bradford	✓	✓	✓	✓	✓	✓	✗	✓
	Exeter	✓	✓	✓	✓	✓	✓	✗	✓
Canada	McMaster	✓	✓	✓	✓	✗	✓	✗	✓
	Dalhousie	✓	✓	✓	✓	✗	✗	✗	✓
Italy	Parma	✓	✓	✓	✓	✗	✓	✓	✓
	Bologna	✓	✓	✓	✓	✗	✓	✓	✓
Singapore	Singapore Institute	✓	✓	✓	✓	✓	✓	✗	✓
	Parkway college	✓	✓	✓	✓	✓	✓	✓	✓
Australia	Sidney	✓	✓	✓	✓	✓	✗	✗	✓
	Monash	✓	✓	✓	✓	✓	✗	✗	✓
	South Australia	✓	✓	✓	✓	✓	✓	✓	✓
South Africa	Durban Technology	✓	✓	✓	✓	✗	✗	✗	✓
Philippine	Holy Angel	✓	✓	✓	✓	✓	✓	✓	✓
Saudi Arabia	King Saud	✓	✓	✓	✓	✓	✓	✓	✓

Japan	Okayama	✓	✓	✓	✓	✓	✓	✓	✓
	Kyorin	✓	✓	✓	✓	✗	✓	✓	✓
China	Hong Kong	✓	✓	✓	✓	✓	✓	✓	✓
Denmark	Metropolitan	✓	✓	✓	✓	✓	✓	✓	✓
Malta	Malta	✓	✓	✓	✓	✓	✓	✓	✓

Type of Program

In some universities, diagnostic radiography and radiotherapy are separated, while in some others they were a combination of therapeutic and diagnostic radiographic dimensions (Table 3). Various models of combining educational topics exist, e.g. the model of Mac Master University (Canada) and University of Parma (Italy). In Mac Master University, students first pass a year of general radiology. Afterward, they can select from three specialized majors of radiotherapy, diagnostic ultrasonography, and diagnostic radiography. In the University of Parma, students first pass radiotherapy physics and nuclear medicine. In the second year, they can complete the specialized studies of radiotherapy techniques and learn nuclear medicine in the third year.

Comprehensive Exam

The criterion for graduation in Iranian universities is success in university examination. However, in some countries, students must pass a national exam to be able to receive a degree. For instance, in Japan, students must participate

in the national radiologist technology exam and obtain the passing score in order to receive a certificate from the Ministry of Health. This examination comprises both therapeutic and diagnostic radiology.

Number of Academic Semesters

In universities of Iran and most countries, a four-year program of Radiologic Technology includes 8 academic semesters based on the semester-credit educational system. In British universities and based on the year-credit, no definition of academic semester exists. However, the three-year program comprises six semesters and hospital internship is during summer is added to the program to make up for the short educational duration. In the US academic system, the duration of B.S. programs differs. For instance, there are 3+1-year programs in the University of Notre Dame and Johns Hopkins University. In the University of Notre Dame, Maryland, the three-year program includes six academic semesters. In the Johns Hopkins University, however, the 18-month program comprises three academic semesters of 5, 6, and 7 months (Tables 7, 8).

Table 7. Presentation of Suitable Pattern for Undergraduate Radiologic Technology Curriculum in Semesters 1-4.

Course Code	Course	Credit Number	Semester
01	Anatomy, Physiology and Pathology (1)	3	First
02	Radiographic Procedures (1)	3	First
03	Evaluation and Interpretation of Medical Images (1)	2	First
04	Apprenticeship (1)	2	First
05	Imaging Sciences (1)	4	First
06	Professional Ethics and Communication Skills (1)	2	First
07	Patient Care and Pharmacology (1)	2	First
08	Medical Terminology	1	First
	Total	19	
01	Anatomy, Physiology and Pathology (2)	3	Second
02	Radiographic Procedures (2)	3	Second
03	Evaluation and Interpretation of Medical Images (2)	2	Second
04	Apprenticeship (2)	2	Second
05	Imaging Sciences (2)	4	Second
06	Professional Ethics and Communication Skills (2)	2	Second
07	Patient Care and Pharmacology (2)	2	Second
08	General Health	1	Second
	Total	19	
01	Anatomy, Physiology and Pathology (3)	3	Third
02	Radiographic Procedures (3)	3	Third
03	Evaluation and Interpretation of Medical Images (3)	2	Third

04	Apprenticeship (3)	2	Third
05	Imaging Sciences (3)	4	Third
06	Biology	2	Third
07	Computer Sciences in Medical Imaging (1)	2	Third
08	Physical Education (1)	1	Third
	Total	19	
01	Anatomy, Physiology and Pathology (4)	3	Fourth
02	Radiographic Procedures (4)	2	Fourth
03	Evaluation and Interpretation of Medical Images (4)	2	Fourth
04	Apprenticeship (4)	2	Fourth
05	Imaging Sciences (4)	4	Fourth
06	General English Language	2	Fourth
07	Computer Sciences in Medical Imaging (2)	2	Fourth
08	Physical Education (2)	1	Fourth
	Total	18	

Table 8. Presentation of Suitable Pattern for Undergraduate Radiologic Technology Curriculum in Semesters 5-8.

Course Code	Course	Credit Number	Semester
01	Sectional Anatomy and Pathology (5)	2	Fifth
02	Techniques and Clinical Aspects of CT Scan (1)	2	Fifth
03	Evaluation and Interpretation of Medical Images (5)	2	Fifth
04	Apprenticeship (5)	2	Fifth
05	Imaging Sciences (5)	2	Fifth
06	Research Methodology in Medical Sciences	2	Fifth
07	Technical Language	2	Fifth
08	Islamic Thought (1)	2	Fifth
	Total	16	
01	Sectional Anatomy and Pathology (6)	2	Sixth
02	Techniques and Clinical Aspects of CT Scan (2)	2	Sixth
03	Evaluation and Interpretation of Medical Images (6)	2	Sixth
04	Apprenticeship (6)	2	Sixth
05	Imaging Sciences (6)	2	Sixth
06	History of Islam	2	Sixth
07	Islamic Thought (2)	2	Sixth
08	Culture and Civilization of Islam and Iran	2	Sixth
	Total	16	
01	Thesis	4	Seventh
02	Imaging Sciences (7)	2	Seventh
03	Techniques and Clinical Aspects of MRI (1)	2	Seventh
04	Islamic Revolution of Iran	2	Seventh
05	Apprenticeship (7)	2	Seventh
06	Family Knowledge	2	Seventh
	Total	14	
01	Imaging Sciences (8)	2	Eighth
02	Techniques and Clinical Aspects of MRI (2)	2	Eighth
03	Evaluation and Interpretation of Medical Images (7)	2	Eighth
04	Apprenticeship (8)	2	Eighth
	Total	8	

DISCUSSION

Radiologic Technology has a special status in medical sciences. Students of this major are familiarized with various method of radiography using ionizing (radiography, CT scan, radiotherapy, nuclear medicine) and non-ionizing radiation (MRI and ultrasonography) [11]. Based on results, the curriculum for B.S. of Radiographic Technology differs based on the presentation of various modalities. Similar to the University of Sydney and Monash University in Australian, Dalhousie University in Canada, and Durban University of Technology in South Africa, Iranian universities do not teach courses related to radiotherapy and nuclear medicine and allocate separate four-year programs to them. However, in most British universities, the noted courses are included in the program. Moreover, some universities present radiotherapy courses in addition to nuclear medicine (Tables 4-6).

In general, the curriculum in Iran and other countries comprise two portions of theoretical and practical sciences. The major features of curricula are starting apprenticeship and familiarization with the hospital environment in the first year, indicating the importance of hospital internship period for learning different radiography techniques and modalities. An important point in the examined curricula is the equality between the number of credits and hours of internship and theoretical courses. For example, in the University of Bradford, the UK, 18 weeks a year belong to academic studies (lectures and educational) and 18 to clinical training. Also, 30 hours a week are allocated to academic studies and 37.5 hours are dedicated to hospital internship. Moreover, at Johns Hopkins University, the US, an 18-month program is offered, comprising a total of 2968 hours, including 2363 of hospital training. On the other hand, in Iranian universities, the total number of credits is 130, 90 of which belong to specialized courses while 16 belong to hospital internship. In other words, the total number of educational hours is 3315 in Iran, from which 1224 hours, i.e. almost one-third, belongs to hospital internship.

Most universities allocate the first year to general courses and fundamental specialized courses such as the principle of psychology,

patient care, and physics of radiation. The second year is dedicated to the expansion of knowledge in medical radiography (radiography techniques) and principles of research methodology. The third and fourth years are dedicated to familiarizing the students with different modalities of special examinations (MRI and CT scan) and hospital internship. Finally, students finish their studies by presenting a research article or thesis (Table 1). This, of course, varies based on university facilities. For instance, in Iran, credits are offered only in the form of hospital internship in the final year. In the first semester, hospital internship for CT scan and special techniques of radiology are offered. In the second semester, MRI, ultrasonography and, in some universities, extracorporeal shock wave lithotripsy (ESWL) hospital internship is offered. Furthermore, anatomy, biology, physiology, and pathology are offered in the first and second years, similar to other universities. These courses are presented separately and the consistency among them is not observed. For instance, in the University of Bologna, Italy, a course entitled "physiology and anatomy" in radiologic sciences and, more specifically, the "anatomy of radiographic techniques" is offered in the first year and the same semester, showing the continuous integration of courses. In the first year, students are offered a credit entitled "sciences of radiographic techniques in radiology 1" in which students first learn about the anatomy and physiology of body organs including the thorax, abdomen, and joints, and then learn the techniques of radiography for the same organs. In the first year, a course called "sciences of radiographic techniques in radiology 2" with 6 credits is offered in which students first learn the anatomy and physiology of urinary system, biliary system, pelvis, and upper and lower limbs and then learn the techniques of radiography for the same organs (upper and lower limbs, barium enema, barium meal, upper gastrointestinal system, hysterosalpingography (HSG), vertebrae, cystography, intravenous urography (IVU), etc.). In the end, students learn about contrast agents and their regulation based on the type of test. However, in the Iranian curriculum, a course named "anatomy 1" with 2 credits is offered in the first semester discussing

topics such as upper and lower limbs and vertebrae. Students also pass a separate course entitled "physiology" with 2 credits including different body systems, without passing any credit on radiographic techniques. In the second semester, students pass "anatomy 2" with 2 credits, including topics such as thorax, torso, and pelvis, followed by "radiographic techniques 1" which discusses radiographic techniques for upper and lower limbs. In the University of Bologna, at the end of the first year, students pass hospital internship with 18 credits. In this course, in addition to learning about hospital environment and different radiography wards, they learn about the techniques of radiography related to the first year. However, in Iran, students pass four credits (102 hours) of hospital internship at the end of the second semester in order to be familiarized with the hospital environment and different radiography wards. It is noteworthy that hospital training and radiotherapy and nuclear medicine techniques are presented in the second and thirds years in the University of Bologna, while no such courses exists in the Iranian curriculum. In the University of South Australia, Monash University, the majority of European universities, and other countries, students in the final year learn about the principle of research in the field of medical sciences while focusing on various radiographic modalities. For example, there are 9 such credits in the University of South Australia and about 27 credits in the Metropolitan University College, Denmark, for research methodology and thesis. In Durban University of Technology, 12 credits in the second year, 12 credits in the third year, and 20 credits in the fourth year are allocated to the foundations of research methodology and conducting a research study. The goal of this credit is familiarizing students with research methodology, how to conduct studies, how to examine new texts, updating information on various radiographic modalities, and preparing them for higher levels of education. In Iranian universities, 2 credits entitled "seminar 1 and 2" are offered to students. After acquiring sufficient scientific and practical knowledge and skills under the supervision of professors, students study various scientific texts including books, journals, magazines, and electronic and Internet

sources and study a field related to medical radiography. After data analysis, results are presented in the form of a written or oral seminar. Based on the opinion of supervisor, "seminar 2" can have a different topic or expand "seminar 1". In Iran, "seminars 1 and 2" are offered in the 7th and 8th semesters or the 5th and 6th semesters, respectively. Thus, we recommend that more hours be allocated to research and presenting theses in Iran similar to most credible universities [12]. In Iranian universities and most universities which offer full-time programs for B.S. of radiographic technology, specialized MRI and CT scan courses are offered in the third year. However, in universities offering three-year programs, these courses are offered in the second year. Skills necessary for a professional radiographer are the ability in communication and psychological skills so that the radiographer can successfully explain the efficiency of diagnostic radiographic methods to patients and their families in order to take an accurate clinical history and offer guidelines during procedures. In most credible universities around the world, this credit has a special significance. For instance, 4.5 credits in the University of South Australia, 8 credits in the Metropolitan University College (Denmark), 3 credits in Mac Master University (Canada), 10 credits in the University of Notre Dame (USA), and 6 credits in the Holy Angel University (Philippines) are offered on this topic, while there is no such course in Iranian universities. Another important topic is presenting a course called "recording and showing images in medicine". In Iran, the general aim of this course is familiarizing students with the principles and concepts of film exposure, the process of photographic processing and recording, and devices related to the darkroom and the radiology ward. Based on the rapid expansion of computer technologies, followed by topics such as electronic patient records, telemedicine, and medical information sciences, digital radiology which had entered medical radiology since the 1980s rapidly replaced the use of films [13]. Of course, the Iranian Ministry of Health and Medical Education (IMHME) has updated the curriculum for radiation technology and used it since 2008 in order to enhance the knowledge of radiologic technologists based on the new

demands of all hospitals and healthcare centers. Nevertheless, after 9 years, teaching of digital radiology devices and Picture archiving and communication system (PACS) is still neglected in Iranian universities, including Lorestan University of Medical Sciences. Meanwhile, most advanced universities around the world attach considerable importance to the physics of digital systems and PACS. For example, because of the movement from traditional to digital radiology, academic courses related to this major are introduced in Japan. In Kumasawa University in Japan, for instance, during the four years of this program, network technology and algorithms and stages of forming digital pictures are introduced in addition to conventional course topics related to digital radiography. This had helped Japanese students adapt themselves to new radiologic devices faster than their European peers and learn the principles of working with them [2]. Another important point is the availability of educational facilities in universities in order to enhance the knowledge of students and teaching in laboratory settings without any stress of potential hazard for students. In Iran, students directly enter the hospital setting after theoretical teaching, a process which poses risk to students and patients. For instance, in Monash University, there are laboratories for radiology and ultrasound which offer three rooms for fixed x-ray equipment, C-ARM system, fluoroscopy, portable radiography, and four high-quality Philips ultrasound systems. In addition, the universities have added an AGFA CR for image processing and a PACS system with workstation to the noted facilities. These appropriate clinical radiographic facilities are used in teaching radiographic techniques. Also, students use virtual learning facilities including simulation software programs for practice and obtaining images with correct exposures in different situation for minimizing the irradiation dose for patients. Results of teaching these techniques were examined in a study by Ogbehi et al, confirming its effectiveness [13]. Ogbehi et al. state that computer simulations provide the opportunity for teaching in a virtual environment. Therefore, learners can improve their professional skill before encountering with a real patient. In Monash University (Australia),

such techniques are introduced using anthropomorphic phantoms supervised by an experienced instructor. Furthermore, evidence suggest that the use of electronic-learning is rapidly growing in world medical centers, with e-learning adding up to 70% of educational time in European medical centers [12], while such programs are not available in Iran. Based on the noted points, a standard curriculum for B.S. of Radiographic Technology is offered in Tables 7 and 8.

A limitation of the present study was the impossibility of direct observations and interviews. Moreover, although updated information from universities was used in this study, some data may not have been completely or precisely recorded in full detail.

CONCLUSION:

The Iranian curriculum does not significantly differ from those of other countries. However, it is necessary to continuously integrate courses, introduce digital image processing subjects, and employ radiography simulation systems in order to enhance the students' learning in the Iranian curriculum for Radiologic Technology.

Conflict of interest: none.

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