

Master of Science in Neuroradiology: A Proposal of a Master's Degree

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ABSTRACT

Studying neurological illnesses and publishing research papers required a medical background. There are few neurology programs that allow other professions –beside MBBS and MD graduates– to study a master's degree in neurology, but neuroradiology field is an exclusive field that is limited for medical graduates only (i.e. MBBS and MD graduates can study it only). This paper is proposing a full-time master's degree curriculum and plan to allow more other professions to study the neuroradiology field to increase the number of the published papers in neuroradiology.

Key words: Neuroradiology; Master's degree; Curriculum; Study plan; Research

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MASTER OF SCIENCE IN NEURORADIOLOGY

There are many neuroimaging master's degrees worldwide that focused on neurocognitive and psychology related imaging. To become a Neuroradiologist, it required an MBBS or MD degree, completion of residency, and fellowship program to become eventually specialized in neuroradiology which is a long path with few candidates. Many Neuroradiologists worldwide focus on their busy clinical medical practice more than the research field. The Neuroradiologists are the one who mostly qualified to make accurate decisions regarding the most important research topics in the field that need more investigation and research. To do a research in neuroradiology, one must know how to interpret neuroradiology scans then the interpreted data must be collected, analyzed, and published. As well, Neuroradiologists are the most qualified one to determine which is the most effective method or approach in studying any neuroradiology topic due to the need for a medical background. Neurocognitive or psychology related imaging can help in diagnosing behavioral issues, but medical illnesses required a medical background and deep understanding of neuroradiology. For example studying cocaine addicts or gamblers by detecting the blood flow to the accumbens nucleus in the brain by fMRI has psychological importance, while neuroradiology is focused more on brain neoplasms, infections, inflammations, neurodegenerative diseases, neurovascular diseases, etc.

There are two theory about publishing research, the first theory is claiming that publishing few papers with high impact and high citation only without publishing the weak papers is the best way to progress in the scientific understanding. The second theory is claiming that publishing more and more papers can generate and help in building a strong knowledge which will lead to progress in the scientific understanding. Even papers with negative results can help in knowing the previous mistakes of previous researchers or proven no relation between two things. By following the second theory –which makes more sense– more researchers in the neuroradiology are needed. In addition, the aim of this program is to prepare the best researchers in the field to publish high quality papers in large numbers which will cause a dra-

matic change in everyone understanding of the nervous system. The nervous system is one of the most mysterious system in the human body which needs more and more studying to improve human knowledge about the nervous system from a radiological point of view.

According to Springer data search for the published papers in 2019, the number of published papers in radiology and imaging are 7,895 papers which comes in the 13 place^[1] compared to the published papers in other medical fields see (Figure 1). Neuroradiology as subspecialty is coming in the 25th place by 3,994 published paper in 2019 in Springer database^[1] which is very low when compared to the published papers in other subspecialties see (Figure 2). It will not cover all the neuroradiology topics. If the published papers in neuroradiology in 2019 even have very important scientific contributions, it will make minimal change and progress.

By making the subspecialty allowed to be studied as a master's degree for the holders of a bachelor degree in health science or neuroscience will allow more neuroradiology papers to be published by qualified neuroradiology specialists. This master's degree will eliminate the need to study all the human systems that a Radiologist required to study like; gastrointestinal, cardiovascular, pulmonary, etc. This master's degree will not qualify those graduate students to become a Neuroradiologist with medical license, but it will allow them to become more specialized and aware of the neuroradiology issues. Many medical specialties are being taught to nurses and medical professionals who are not physicians like: cardiovascular, ob/gyn, neurology, orthopedic, etc. The only field that is isolated is the neuroradiology and it is only allowed for Neuroradiologists, Neurologists, and Neurosurgeons to be involved with the advanced topics to be discussed among them. By allowing more qualified neuroradiology specialists to lead the research in this field, it will make a difference.

In psychiatry and psychology, Psychiatrists and Psychologists are not involved in neuroradiology and there was some published books like Images of Human Behavior by Daniel Amen where he claim that SPECT scan can help in imaging of mental illnesses and it's a major breakthrough in psychiatry^[2]. This book shows the relation between a clinical mental illness and the imaging pattern of this illness. Another book is the psychopath inside by James Fallon which shows the relation between the prefrontal cortex damage on SPECT images and the lack of empathy in serial killers^[3]. This proves the extent of the neuroimaging abroad many specialties and fields. The need to make neuroradiology and neuroimaging available as master's degrees worldwide is an urgent necessity now. There are few neuroimaging master's programs and maybe one or two neuroradiology programs worldwide.

The neuroimaging programs usually focus on topics that are more neuroscience and psychology oriented and focused on topics like: brain mapping, connectome, white matter diseases, addiction, mental illnesses in relation with atrophied region with no blood flow, myelination, etc. None of the neuroimaging programs involved in neuroradiology topics like chiari malformation, ischemic stroke, carotid dissection, etc.

Designing a master's degree that allows the master's degree graduates to be familiar with all the neuroradiology topics will allow high quality research to be published in the field of the neuroradiology. The master's program can be organized to be studied by the region, disease, or age and gender.

CURRICULUM DESIGN

The curriculum design for this master program can be organized to cover all the topics in the neuroradiology field see (Tables 1, 2, and 3).

Internal Medicine	26,795
Pharmacology/Toxicology	18,699
Drug Safety and Pharmacovigilance	16,491
Oncology	14,347
Pathology	12,913
Public Health	10,954
Medicine/Public Health, general	9,489
Laboratory Medicine	9,315
Medical Biochemistry	9,218
Cardiology	9,130
Neurology	8,326
Surgery	8,271
Imaging / Radiology	7,895
Orthopedics	7,834
Pediatrics	7,568
Gastroenterology	6,799
General Practice / Family Medicine	6,793

Figure 1 The number of published papers by specialty in Springer database in 2019.

Endocrinology	5,079
Neurosurgery	5,057
Surgical Oncology	4,804
Urology	4,447
Surgical Orthopedics	4,356
Emergency Medicine	4,324
Epidemiology	4,086
Neuroradiology	3,994
Rheumatology	3,953
Hepatology	3,835
Pain Medicine	3,740
Anesthesiology	3,734
Hematology	3,600
Otorhinolaryngology	3,530
Infectious Diseases	3,504
Abdominal Surgery	3,198
Diabetes	3,193

Figure 2 Neuroradiology is in 25th place with 3,994 papers in 2019 on Springer database.

The program can be organized as the following:

Admission requirements: The candidate must possess a bachelor with a GPA of 3 out of 4 from a recognized university in health science or neuroscience. The students with a bachelor degree in health science or neuroscience (non-physician) are not allowed to take track (B) the clinical internship pathway. To stop the admission exclusivity issue, even MBBS and MD graduates can join this program to help them to get accepted in the competitive residency positions in radiology. Any MBBS and MD graduates can join this program and continue in the clinical internship or the thesis track. English language proficiency test for non-English speakers is required. A candidate must score on IELTS test the score of 6.5 out of 9 or the equivalent score of a TOEFL test.

Assessment and evaluation: The assessment is based on written examinations, seminars, case presentations, dissertation, publishing a paper (with the M.Sc. thesis or a case report, review, any scientific

Table 1 Curriculum design based on the region.

Subject	Course credit
Neuroanatomy and neuropathology	6
Neuropharmacology and neurosurgery	3
Neuroimaging techniques (PET, SPECT, MRI, CT, US (TCU), EEG, MEG, and TCM)	6
Neuroradiology (brain)	5
Neuroradiology (spine)	3
Neuroradiology (related structure)	1
Bio-statistics	2
Research methods	3
Image artifacts and patient safety during clinical trial	6
Track (A) master's degree thesis or Track (B) clinical internship for MBBS and MD holders	4
Seminar	1
Total	40

paper during the clinical internship). The student must publish a paper by the end of this program in a journal listed on Web of Science which owned by Clarivate previously known as institute for scientific information (ISI) previously owned by Thomson Reuters Corporation.

Career prospective: The job prospective is mainly in research with this medical dense program that produce high experts in the field. The graduates can work in pharmaceutical companies who are testing neuro- pharmaceuticals and need neuroimaging scans and interpretations of the effects on MRI scans or any medical imaging modalities. This master program's graduate can join any research teams worldwide and any research program in any university to conduct research in the field. As well, the graduate could join any educational position in any university as Lecturer in neuroradiology. It could help in some countries like the United Kingdom where they allow advanced position for Consultant Radiographers who interpret radiology scans due to the shortage of Radiologists. This program can help the reporting Radiographers by a condense program in neuroradiology and in brain scan interpretation of the CT scans. This master's degree can help the students with an MBBS or MD to be accepted in a competitive residency and fellowship programs with a strong subspecialty qualification in neuroradiology. As well, it will help the students to be more familiar with research cycle and publishing papers in prestigious journals.

Name and length of the qualification: The qualification formal name is a "Master of Science in Neuroradiology" which can be abbreviated as M.Sc. in Neuroradiology. The master's program is two years long (full-time) and 40 credit required for graduation.

Accreditation: Due to the lack of master's degree in neuroradiology, this master's degree is not accredited by any health authorities worldwide. It can be considered as an interdisciplinary or professional program.

Advances in the field: There are too many technologies related to the field of neuroradiology. Every day there is a new pulse sequence, contrast media, imaging protocol, scanning machine, reported case or technique, artificial intelligence break through, new method, or new discovery which are welcome to discuss these topics in the weekly seminar.

Clinical internship: The clinical internship is at the end of the program (last semester), so the students can practice with what they have learned in the master program. The internship must be focused on neuroradiology, to be done in an accredited hospital, and under supervision of a qualified Neuroradiologist.

Table 2 Curriculum design based on the disease.

Subject	Course credit
Neuroanatomy and neuropathology	6
Neuropharmacology and neurosurgery	3
Neuroimaging techniques (PET, SPECT, MRI, CT, US (TCU), EEG, MEG, and TCM)	6
Neuroradiology of neurovascular diseases	3
Neuroradiology of neuroinflammatory diseases	3
Neuroradiology of neoplasms	3
Bio-statistics	2
Research methods	3
Image artifacts and patient safety during clinical trial	6
Track (A) master's degree thesis or Track (B) clinical internship for MBBS and MD holders	4
Seminar	1
Total	40

Table 3 Curriculum design based on the age and gender.

Subject	Course credit
Neuroanatomy and neuropathology	6
Neuropharmacology and neurosurgery	3
Neuroimaging techniques (PET, SPECT, MRI, CT, US (TCU), EEG, MEG, and TCM)	6
Adult neuroradiology	4
Pediatric neuroradiology	2
Maternal related and neonatal neuroradiology	1
Geriatric neuroradiology	2
Bio-statistics	2
Research methods	3
Image artifacts and patient safety during clinical trial	6
Track (A) master's degree thesis or Track (B) clinical internship for MBBS and MD holders	4
Seminar	1
Total	40

A Ph.D. program in neuroradiology: After having a successful experience with establishing the proposed master's degree and evaluating the success rates of the M.Sc. graduates in finding jobs in the research field. A Ph.D. program can be established with a subspecialty in neurodegenerative diseases, neurovascular diseases, etc. The Ph.D. graduates can participate in one specific field to become a skilled researcher in the selected field. The Ph.D. program prepares top experts in neuroradiology to lead the research wheel toward huge scientific achievements. The Ph.D. graduate student can join any post-doctoral fellowship program.

Modification of the proposed points: All the proposed points in the curriculum design, admission requirements, accreditation, assessment & evaluation methods, and academic tracks can be adopted from this paper or can be modified to become more suitable for the needs of the job market.

HOW MANY UNIVERSITY OFFERS A SIMILAR MASTER'S DEGREE IN NEURORADIOLOGY?

To the best of our knowledge, there are only two programs, one is offered by the Universitat Autònoma de Barcelona in Barcelona Spain^[4] and another one is offered by Karlsruhe Institute in Stockholm Sweden^[5]. With the programs still accept students now or not, this information is not available to us to the date of publishing of this paper.

CONCLUSION

A master program in neuroradiology will be a game changer in the neuroradiology field. Any university will offer this program can become one of the leading universities with this unique type of master's program. A Ph.D. program can be established to allow more positive progress.

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