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FULL PAPER

Radiology for medical students: Do we teach enough? A national study

[1,2,3]CINDY CHEW, MB ChB, MRCS, FRCR, MSc(Research), [2]PATRICK J O'DWYER, MCH, FRCS and [4]EUAN SANDILANDS, MD, FRCP(Edin), PGCert (MedEd)

[1]Department of Radiology, University Hospital Hairmyres, Hairmyres, United Kingdom
[2]School of Medicine, Dentistry and Nursing, University of Glasgow, Scotland, United Kingdom
[3]NHS Lanarkshire Department of Medical Education, Kirklands Hospital, Scotland, United Kingdom
[4]Edinburgh Medical School, Edinburgh, United Kingdom

Address correspondence to: Dr Cindy Chew
E-mail: *chewszewan@aol.com*

Objective A recent study has shown that the averaged time tabled teaching for a medical student across 5 years in the UK was 4629 hours. Radiology has been demonstrated to be an excellent teaching source, yet the number of hours allocated to this has never been calculated.
The aims of this study were to evaluate and quantify the hours allocated to radiology teaching in Scottish Medical Schools and to evaluate if they can fulfil requirements expected from other Clinical disciplines and the upcoming General Medical Council Medical Licensing Assessment (GMC MLA).
Methods Data pertaining to timetabled teaching for Radiology in Scottish Universities were obtained from the authors of the Analysis of Teaching of Medical Schools (AToMS) survey. In addition, University Lead Clinician Teachers were surveyed on the radiological investigations and skills medical students should have at graduation.
Results Medical students in Scottish Universities were allocated 59 h in Radiology (0.3%) out of a total 19,325 h of timetabled teaching. Hospital-based teaching was variable and ranged from 0 to 31 h. Almost half (15 of 31) of Clinician Teachers felt that there was insufficient radiology teaching in their specialty. Thirteen of 30 conditions included in the GMC MLA were listed by Clinician Teachers, while 23 others not listed by the GMC were considered important and cited by them.
Conclusion This study demonstrates that medical students do not receive enough radiology teaching. This needs to be addressed by Universities in collaboration with the NHS in an effort to bring up this up to line with other developed countries and prepare students for the GMC MLA.
Advances in knowledge (1) There is insufficient time allocated in Medical Students' curriculum to Radiology.
(2) Radiology teaching in medical schools fall short of University Lead Clinician Teachers' and GMC expectations of medical students at graduation.

BACKGROUND

A recent study by McManus et al moved the quantitative evaluation of medical school education a step forward in 2020 analysing 47,258 timetabled events from the academic year 2014/15 to quantify what, when and how medical students were taught in 25 UK medical schools and linking that to postgraduate outcomes and fitness to practice.[1,2] They demonstrated that while more teaching in General Practice (GP) resulted in more graduates entering GP training, this correlation did not hold for teaching in psychiatry, surgery and anaesthetics.[2] Students from problem-based learning (PBL) schools were shown to have higher satisfaction with feedback but lower performance at post-graduate examinations, although the latter may be related to lower entry grade to university.[2]

The total timetabled event at each standardised 5-year medical school for an average student was calculated at 4629 h (range 3543 to 6205 h, SD 657). While timetabled teaching events were intended for every student, it was acknowledged that actual student attendance and engagement might not necessarily follow. Nevertheless, if little actual time is timetabled for a specific subject or activity, then it is a reasonable assumption that little is actually done on that subject/activity.[1]

While radiology have been espoused as an excellent teaching tool for medical students for almost 100 years[3], with extensive inclusion of this subject in medical student education in Europe and America, there is no concrete data on the hours timetabled for this subject for the UK. Further,

the GMC is due to roll out a medical licensing assessment in 2025 for all UK medical students.[4] As part of the assessment, the GMC has listed a number of conditions for each specialty that could be examined. Included is Clinical Imaging with 30 conditions, making it one of the top 10 specialties in the category.

The aims of this study were to evaluate and quantify the hours allocated to radiology teaching in Scottish Medical Schools[2] and to evaluate if they can fulfil requirements expected from other clinical disciplines and the upcoming General Medical Council Medical Licensing Assessment (GMC MLA).

METHODS

Institutional board review was waived as this study involved only administrative data of medical school timetables, the results of which have already been published and no personal data were handled. Institutional board review was also waived for the survey as it was considered part of normal process to inform and evaluate teaching and learning.

Radiology teaching—The Analysis of Teaching of Medical Schools (AToMS) survey sub-analysis

The authors of the AToMS study, as well as the Medical Student Investigators Collaborative (MSICo), were contacted for permission to access the Scottish component of their detailed analysis of timetabled teaching events. Data pertaining to all timetabled teaching in 2015 for the Medical Schools of the Universities of Aberdeen, Dundee, Edinburgh and Glasgow were received. These timetables were previously validated against the Higher Education Policy Institute (HEPI) Student Academic Experience Survey as well as the study of teaching of general practice, which collected data from heads of Departments of General Practice in UK medical schools.[1,5]

Detailed analysis of each medical school was performed to quantify the presence, duration and type of teaching by radiology in the timetabled curriculum. The analysis involved hand-searching by a consultant Radiologist of the AToMs data set to identify radiology teaching. In addition, the search was supplemented with AI technology in computer vision and optical character recognition to extract words in scanned documents, to improve the search. A bespoke data transformation pipeline was built using Open Source Tesseract 4.1 (GitHub 2020), Poppler 0.84 (FreeDesktop 2020), LibreOffice CLI Tools 6.4 (LibreOffice, 2020), Penhaho Community Edition 9.0 (Hitachi Vantara, 2020, Tokyo, Japan) and the standard toolset in Fedora 32 (Fedora Project, 2020). These tools collectively extract data from the portal document formats (PDFs) and store the contents to the disk. The data are then cleaned, moulded to a unified model and key words identified, extracted and then visualised. Tesseract leverages a pre-built Neural Network for optical character recognition of PDFs, was leveraged where necessary with appropriate thresholds on character classification. This process ensured that the search was complete. Keywords used included "radiology", "radiologic", "imaging", "CT", "MRI", "US", "ultrasound", "X-ray", "x-ray" and "xray". While the list was not exhaustive, this automated program was intended to ensure complete and independent verification of the data, and the terms used reflected information already gleaned from the hand search component of the analysis.

Universities lead clinician teachers survey

All four Scottish Medical Schools were contacted to participate in an anonymous online survey to find out what lead clinician teachers thought about radiology teaching and what they felt were the five most important radiology-related knowledge/skills medical students need to graduate with. Lead Clinician teachers from each university, comprising a wide range of subjects and disciplines were included. Principles described by Philips et al were adhered to in order to maximise participation.[6] The survey was open for 6 weeks and one reminder email was sent a week before closing.

GMC

The GMC Website with information on Medical Licensing Assessment was accessed on 31 August 2020.

RESULTS

The raw data from the 2015 Freedom of Information request for Universities of Aberdeen, Dundee, Edinburgh and Glasgow were evaluated. All four had standard 5-year courses, with University of Glasgow being the only PBL-aligned school. The total number of hours of teaching ranged from 3982 (Glasgow) to 5446 (Dundee), with Edinburgh (4828) and Aberdeen (5069) in between.

Radiology content is delivered across all 5 years for most universities. Although more hours of radiology teaching appear to be within the clinical years (Years 3–5), the content and hours delivered had a high degree of variability. Radiology content delivered in Years 1 and 2 appeared more standardised, largely related to the subject matter and method of content delivery (anatomic imaging, tutorial/lectures). These data are summarised in Tables 1 and 2 [Years 1 & 2, Years 3–5 (standardised University based teaching)], and Appendix 1: Years 3–5 (non-standardised, Hospital-based teaching).

Non-standardised hospital-based teaching in radiology was listed in three of the four medical schools' time tables. Many listed radiology teaching hours attributed had no time allocation. Total time listed ranged between 0 and 31 h for hospitals that listed teaching hours, details of which are included in Appendix 1.

The total hours of University-based radiology teaching was 59.1, representing 0.3% (range 0.02–0.75%) of total teaching time for all Scottish Medical Schools (Table 3).

Universities lead clinician teachers survey

Glasgow and Edinburgh University Medical Schools agreed to participate in the survey (Appendix 2). Fifty-three lead clinician teachers were contacted. Thirty-one responses were collected giving a response rate of 58%. The clinical specialities represented are shown in Appendix 3.

Thirty (97%) responded positively to the question "Is Radiology teaching in your specialty important for medical students?"

Table 1. University based Radiology Teaching in Years 1 & 2

University	Subjects Year 1	Hours	Subjects Year 2	Hours	Total Hours
Aberdeen		0	Alimentary Tract	1.5	1.5
Dundee	Gastro-Intestinal Anatomy (small group), Thorax, Musculo-Skeletal, Cardiovascular system, Respiratory, Gastro-Intestinal and Genito-Urinary	11	Renal Anatomy, Common Urological and Renal disease, Ear Nose & Throat, Spine and Arthritis (principles in Imaging), Upper limb trauma, Lower limb trauma, CT/MRI/US in trauma.	5.6	16.6
Edinburgh	Body Imaging	1			1
Glasgow	Intro + 5 weeks Basic Body Radiologic Anatomy	6	Gastro-Intestinal Radiology	1	7

Table 2. University based Radiology Teaching Years 3–5

University	Subjects Year 3	Hours	Subjects Year 4	Hours	Subjects Year 5	Hours	Total Hours
Aberdeen		0	Paediatrics, Respiratory, Alimentary tract, Urinary system, Neurology, Genito-Urinary/ Reproductive system	6	Radiation Protection CXR essential skill part of Surgical Procedures	1.5 ?	7.5 + ?
Dundee	Radiology joint pain (small group)	1.5	US in Obstetrics + Gynaecology	1		0	2.5
Edinburgh		0		0		0	0
Glasgow	CXR Radiology small group teaching day; seven lectures (covering CXR, Genito-Urinary, Lines, Arthritis, AXR)	10	Trauma upper and lower limb Small group Radiology Day.	7	Revision Radiation Protection Paediatric Radiology Cardiac imaging	6.5	23.5

AXR, Abdominal X-ray; CXR, Chest X-ray; US, Ultrasound.

Radiology was used "frequently" in 27 (87%) of respondents' specialty. Fifteen (48%) stated there was insufficient radiology teaching related to their speciality for medical students. Twenty-four (77%) respondents stated they taught radiology related to their specialty to students.

Table 4 lists the radiological images and skills lead clinician teachers thought medical students should have knowledge in at graduation. Chest X-ray was by far the most common image skill cited, with 24 (77%) of the respondents rating it as important. Thirteen of 30 (43%) conditions included in the MLA were also listed by Clinician Teachers as essential knowledge for medical students (Table 5). Seventeen conditions on the GMC MLA list were not mentioned by clinician teachers, while 23 conditions considered important by clinician teachers were not included in the content map.

Table 3. University-based Radiology teaching hours as a proportion of total teaching hours per University

University	Radiology Teaching (Hours)	Total teaching (Hours)	% of Total Teaching
Dundee	19.1	5446	0.35
Edinburgh	1	4828	0.02
Aberdeen	9	5069	0.18
Glasgow	30	3982	0.75
Total	59.1	19,325	0.31

DISCUSSION

Radiology is deemed as important for medical student education by University Lead Clinician Teachers and the GMC. Clinical imaging features significantly in the GMC MLA content map. Tellingly, a surprisingly large number of conditions clinician teachers felt were important for students to know were not included in the GMC's content map, echoing the findings from previous studies.[7,8]

Given the importance of radiology to modern medicine, it is surprising the limited hours, 59 out of 19,325 teaching hours, allocated to this subject by Universities. Radiology is clearly

Table 4. Clinician Teachers' list of Radiologic image/skills medical students should have knowledge in

Topic	Respondents (N)
Chest X-ray	24
What imaging to request	12
Indications for Tests/ When to/ not to Image	12
CT/MRI Brain	9
Abdominal X-ray	7
CT Chest	6
CT Abdomen Pelvis	6
Musculo-Skeletal X-ray	5
Ultrasound Abdomen	4
How patients get the tests	3
Renal impairment + Contrast+Guidelines	2
Risks and Benefits of Imaging	2
Importance of speaking to Radiologist	2
How to read all modalities	2
Guidelines on imaging	1
Some knowledge of CT	1
Basic reading of CT	1
Some understanding of CT/MRI	1
Nasogastric Tube/Endotracheal Tube position	1
CT/MR Orbits	1
Cholangiogram	1
Common Paediatric X-ray	1
Soft tissue X-ray for oesophageal foreign body	1

underrepresented in the curriculum. Compared to Europe and the USA, the UK falls far short not just in time allocated to radiology teaching, but also in the standardised ways the teaching should be conducted.[5,9–11] This is a long standing problem, which is compounded by a backdrop of one-third of Scottish consultant radiologist posts being unfilled.[12,13] Already, the hours reported by Scottish radiologists spent teaching are reduced from that reported for the UK previously.[5,14]

In parallel with other UK universities, and unlike most European and American medical schools, clinical radiology teaching in Scotland is not a stand-alone subject (*e.g.,* general practice or child health) and most commonly occurs when students are in medicine, surgery or paediatric clinical placements.[5,10,11] Some universities provided radiology teaching in cardiology as well as in trauma and obstetrics and gynaecology. While we acknowledge that the calculated hours attributable to radiology teaching (by both clinicians and radiologists) may be under estimated in this study, the lack of standardised radiology teaching is in stark contrast to both clinician teachers' and GMC expectations.

Our study shows that, in keeping with the literature, there is rightly a focus on the role of radiology in teaching Anatomy.[15] A recent study has demonstrated that Radiology teaching significantly improved Anatomy scores, difference of 5.50 points (95% C.I. 3.31–7.70; $p < 0.001$).[16] While there is currently little objective evidence to demonstrate radiology teaching in clinical medicine improves student outcome, nonetheless, we have demonstrated a large gap between what students are expected to know in clinical imaging and what they are taught.

A particular issue raised by our study is that radiology teaching content remains hugely variable, despite the Royal College of Radiologists undergraduate curriculum and GMC outcomes for graduates.[17,18] While most radiologists want to teach medical students,[14] hospital-based teaching is variable and difficult to quantify. Without being allocated time in the curriculum, it is difficult for even for the most enthusiastic radiology teacher to meet the high bar of expected requirements, even with the use of innovative teaching tools.[9,19,20]

How can we change this? European Radiological Society suggests initiatives including e-Learning, flipped classrooms, simulating diagnostic reasoning using imaging, problem solving scenarios and the use of simulations.[9] In the USA, action plans called for integrated medical imaging training with standardised educational resource across all years of the curriculum. This would be developed by having a nationally recognised core imaging curriculum with both didactic and digital interactive material.[10] While a "radiology block / clerkship" is probably not achievable or necessarily required in the UK context, a coherent, standardised and consistent program of radiology teaching and learning, interspersed and embedded throughout clinical and pre-clinical years is urgently needed. This could take the form of face to face lectures or online learning – particularly now in the era of the covid pandemic.[11] Students' access to wards and patients may be curtailed, but they can still be taught clinical medicine - by "seeing" patients virtually via their imaging and electronic records. Authentic and relevant learning, observing how clinical information in combination with clinical imaging form a powerful diagnostic coupling, will help students learn clinical reasoning, appropriateness and limitations of radiologic investigations and ground them in the practice of realistic, personalised medicine. Ultimately, this should make for better doctors, reduce cost and improve patient outcome. For this to happen, there needs to be buy-in by stakeholders: Universities, Health Boards, Royal College of Radiologists and radiologists. There will also be a need for Faculty development among radiologists interested in medical student education.

Limitations

There are a number of limitations to our studies. The curriculum data analysed in this study are only for Scottish Universities from 2015. While these data are not most up to date, it provides a detailed snap shot of Scottish Medical School curriculum at the time and has been validated by three external datasets.[1,21,22] In Glasgow, there has been only very slight increase in the time allocated to radiology/student compared to 2015. Edinburgh University has recently introduced a compulsory, additional

Table 5. Conditions in GMC MLA content map correlated to list compiled from Clinician Teacher survey

GMC MLA and Clinician Teachers ($N = 13$)	GMC MLA but not Clinician Teachers ($N = 17$)	Clinician Teachers but not GMC MLA ($N = 23$)
Cardiac Failure	Aneurysms, ischaemic limb and occlusions	Acute Kidney Injury
Extradural haemorrhage	Bladder cancer	Biliary abnormalities
Lower limb fractures	Breast cancer	Cerebral Abscess
Lung cancer	Bronchiectasis	Chronic Kidney Injury
Pneumonia	Colorectal tumours	Corda equina syndrome
Pneumothorax	Intestinal ischaemia	Developmental Dysplasia Hips
Pulmonary embolism	Intestinal obstruction and ileus	Demyelinating disease
Raised intracranial pressure	Intussusception	Deep Venous Thrombosis
Spinal cord compression	Lower limb soft tissue injury	DVT in pregnancy (DVT)
Stroke	Osteomyelitis	Endocrine imaging (adrenals, thyroid, parathyroid
Subarachnoid haemorrhage	Pathological fracture	Hydrocephalus
Subdural haemorrhage	Placenta praevia	Hydronephrosis
Upper limb fractures	Spinal cord injury	Inflammatory bowel disease
	Spinal fracture	Imaging in Iron Deficiency Anaemia
	Surgical site infection	Lymphoma
	Upper limb soft tissue injury	Mastoid abscess
	Volvulus	Mediastinal shift
		Mediastinitis
		Nasal polyps
		Oesophageal foreign body
		Peri-orbital cellulitis
		Pleural effusion
		Slipped upper femoral epiphysis

Plus : role of radiology in Anatomy, Clinical reasoning.

Bachelor of Science component into its program after year 2. Similarly, this does not materially affect hours attributable to radiology teaching.

Total radiology teaching, particularly during clinical blocks is likely under estimated. However, as non-standardised teaching sessions were not available to all students within the medical schools and were not listed on time tables it was impossible therefore to include these as percentage of total teaching hours.

Only two of the four Scottish Medical Schools responded and participated in the survey. However, with over 30 respondents and almost 60% response rate across a wide range of clinical specialties, we considered the results a fair representation of the opinion of university lead clinician teachers. Finally, as the data represented outcomes from two time periods, comparing statistics between survey responses and hours taught was not possible.

CONCLUSION

This study demonstrates that medical students receive very little Radiology teaching. This needs to be addressed by Universities in collaboration with the NHS in an effort to bring up this up to line with other developed countries, and prepare students for the GMC MLA.

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COMPETING INTERESTS

No conflict of interest.

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