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Xu, Y, Pervez, A, Theodoulou, I et al. (6 more authors) (2021) Future Interventional Radiologists and Where to Find Them—Insights from Five UK Interventional Radiology Symposia for Junior Doctors and Medical Students. *Cardiovascular and Interventional Radiology*, 44 (2). pp. 300-307. ISSN 0174-1551

<https://doi.org/10.1007/s00270-020-02655-7>

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Introduction

Interventional radiology (IR) has gained increasing recognition in modern hospital medicine, paralleled by growing demands and rapid expansion in both emergency and elective patient care. However, there is a significant shortage of interventional radiologists (IRs) in the UK. 45% of the services in England are not able to provide out-of-hours access to IR due to a 36% (or 379) shortfall of IRs. A shortage of suitably trained candidates has been identified as one of the major contributors to this workforce crisis [1].

The current IR training in the UK consists of two stages over a total of six years (*Figure 1*), with three years in core training and three years in IR specialist training. The core training programme is a common pathway for both diagnostic and interventional radiology candidates. Postgraduate doctors can apply to enter the radiology core training after they finish their two-year foundation training programme, or at any later stages (e.g. during core or high specialty training in other specialties, or at equivalent non-training grades). Only following successful completion of the core radiology training, can trainees then undertake dedicated IR specialty training for another three years. A Certificate of Completion of Training (CCT) is required for the individual to be added to the specialty registry on completion of training, and the European Board of Interventional Radiology (EBIR) accreditation is currently not mandatory. While this pathway provides a solid ground in diagnostic radiology, the IR recruitment process is relatively disjointed.

Recent studies have shown that IR is underrepresented in medical school's curricula and medical students' exposure is generally inadequate in the UK and the rest of Europe [2, 3, 4, 5]. It has been suggested that the lack of exposure and knowledge demotivate medical students from pursuing a career in IR [6]. The introduction of IR curricula from the Cardiovascular and Interventional Radiological Society of Europe (CIRSE) and the British Society of Radiology (BSIR) for medical students [7, 8] is expected to have a positive impact at the undergraduate level. A variety of outreach schemes run by professional organisations continue to engage undergraduate students and postgraduate doctors, including those organised by CIRSE and BSIR.

Additionally, one-day symposia, a cost-effective recruitment strategy used by IR and many other specialties [9], have rapidly gained popularity in the UK in response to the increasing demand to supplement IR knowledge and career insights in the extra-curricular domain. There was a record-breaking total of five IR symposia held between September 2019 and February 2020 (*Table 1*) and a few more scheduled but disrupted by the COVID-19 pandemic. While some were IR specific, some events also included educational diagnostic radiology topics to increase their audience base. Most events featured inspirational talks, career insights, practical skills

workshops and networking opportunities. The target audiences were mainly junior doctors not currently in radiology training and medical students; radiology core trainees were also welcomed.

The attendees of these symposia form a unique cohort with pre-established interests in IR. This presents an opportunity to explore the contributing factors during their undergraduate and postgraduate training that encouraged them to consider becoming IRs. This study will supplement the current knowledge primarily drawn from blanket surveys on general medical student populations [2, 3]. It will also help the IR community to better focus the efforts on recruiting and nurturing the next-generation IRs.

Methods

Anonymised questionnaires were distributed either in paper or digital formats to attendees at the abovementioned five events. The questionnaire includes fifteen questions covering basic demographics, qualitative and quantitative assessment on prior IR exposure, and subjective opinions (*Supplement 1*). Individuals who attended multiple events were surveyed once. For the Bart's National Undergraduate Radiology Conference (BURC), only responses from those who specifically expressed interest in the IR aspect of the event were collected.

The subjects were categorised according to their stage of training. In addition, foundation trainees, non-radiology core and high specialty trainees (or equivalent) and radiology core trainees were grouped together as the 'junior doctors' subgroup, as opposed to medical students who may yet to have more IR exposure at medical schools. Subjects in the 'junior doctors' group have exposures beyond the undergraduate level of IR experience and are more likely to face near-term career choices.

Categorical variables were compared using Chi-square tests, or Fisher's exact test when appropriate. Numeric variables were compared using independent or paired T test as appropriate. The correlations between discrete numeric variables were analysed using Pearson R test. Multivariate binary logistic regression was performed on the 'junior doctors' group. P values <0.05 were considered statistically significant. Statistical analyses were carried out with SPSS version 25.

Results

A total of 220 valid responses were obtained from similar numbers of male and female subjects (*Table 2*). The overall response rate was at 90%. The proportion of audiences' stage of training varied by event, reflecting each event's target audience group. Among those that responded to the survey, 82% (N=181) first learnt about IR

during medical school; however, 18% (N=39) only came across IR during their postgraduate training. The vast majority (95%, N=163) became interested in IR by the Foundation stage of training, a large proportion (57%, N=125) of which were during their clinical undergraduate training.

With regards to prior IR experiences, 38% (N=84) considered themselves having had more exposure than their peers and 50% (N=109) at similar levels, which reflects their objective exposure (in broad categories of undergraduate experience, clinical involvement, and portfolio and career preparation; data not shown) with a strong positive correlation (Pearson's $R=0.49$, $p < 0.001$). Overall, 81% (N=177) did not consider the undergraduate curricular IR exposure sufficient, while 16% (N=34) were unsure. 84% (N=184) were not aware of any published IR undergraduate curricula. Moreover, 78% (N=172) were unsure or did not feel there were sufficient extra-curricular IR opportunities either. Among them, 35% (N=61) and 74% (N=127) have not engaged with BSIR or CIRSE, respectively. In total, 85% (N=186) were supportive of creating a portal website dedicated to providing information on IR-related events and resources for junior doctors and medical students.

Prior to the events, 61% (N=134) subjects felt 'likely' or 'very likely' to pursue a career in IR while 31% (N=69) felt 'neutral', which is positively correlated with objective exposures (Pearson's $R=0.40$, $P < 0.001$). With 97% (N=213) good ratings, the symposia had a positive impact on recruitment (*Figure 2*) by having individuals remain as willing or become increasingly willing to consider a career in IR (mean post-event Likert scale score 3.93 ± 0.83 vs. pre-event score 3.78 ± 0.87 , $p < 0.01$). The effects were equally marked among the postgraduate doctors and medical students (mean post-event Likert scale score increases 0.14 ± 0.53 vs. 0.16 ± 0.46 , $p = 0.68$). Of note, the symposia had particularly pronounced effects for female than male attendees (mean post-event Likert scale score increase 0.21 ± 0.55 vs. 0.10 ± 0.44 , $p = 0.01$).

In the 'junior doctors' group, the correlations between subjective and objective assessments of exposure (Pearson's $R=0.44$, $p < 0.001$), and between exposure and likelihood to pursue an IR career (Pearson's $R=0.35$, $p < 0.001$) remain strongly positive. Their prior IR exposure was divided into several categories as shown in *Table 3*. The number of days spent on IR-related learning during medical school, capturing various formats of IR education e.g. lectures, tutorials, placements and student-selected component/elective modules, is more reflective of the quantity of undergraduate curricular experience (*Figure 3*). There were only 9 responses to 'postgraduate teaching on IR' and this was therefore excluded from further analysis, as teaching for postgraduate trainees tends to be heterogenous and firm-focused. Univariate analysis showed that the subjective likelihood of junior doctors to choose IR was significantly positive associations with days in IR-related learning

during medical school, clinical involvement, and portfolio and career preparations. Other factors such as gender, an early interest in IR since medical school and membership/junior committee role with professional organisations do not demonstrate statistically significant associations. Multivariate logistic regression analysis further shows clinical involvement is the primary independent contributing factor to a subject's likelihood to pursue an IR career. Exposure to clinical activities makes it 3.6 times more likely [95% confidence interval 1.21-10.50] for a postgraduate doctor to feel positive about pursuing an IR career.

Discussion

In our study, we had high response rates from attendees of five IR-related symposia in the UK, which helped to form a large and unique cohort of mixed junior doctors and medical students with overall good prior exposure to IR and positive views towards an IR career, as oppose to a less exposed general population of junior doctors and medical students.

A strong correlation between IR exposure and an individual's subjective likelihood to pursue an IR career is observed. In particular, involvement in clinical activities such as procedures, interdisciplinary decision-making and outpatient consultations have the most significant contribution. It is also observed that more aspiring individuals spend more time in IR-related learning with an average of 8.4 days. While this is potentially achievable within standard undergraduate curricula, this high number was mainly attributed to a few individuals' exceptional experiences, such as choosing IR for student-selective modules and electives of 2 to 9 weeks. Whilst portfolio and career preparation experiences remain important for a few subjects, they do not reach statistical significance as an independent factor contributing to the subject's likelihood to pursue an IR career. One potential reason is that IRs' supervision time for non-IR junior doctors and students in non-clinical domains is limited and therefore can target only a small number of exceptionally motivated individuals. It should also be noted that gender is not a determinant of individuals' attitude towards an IR career in our cohort, which may be partly due to equality campaigns helping to reshape the IR professional image. Of interest, the symposia had more marked effects on the female attendees' career interest in IR. This finding is coincided by a previous study on an intensive weekend course from Australasia [10]. In our study, all five events featured female IR speakers or workshop tutors acting as role models. Also, concerns and questions about gender-specific areas may have been addressed informally through interactions during networking sessions. Our survey did not specifically enquire about perceived or experienced barriers for female students and doctors to pursue IR careers, such as fear of radiation exposure in child bearing age [11], and this can be a focus for future studies.

This study again highlights the insufficiency of IR exposure at undergraduate level, in line with existing literature [2, 3, 12]. We have selected a more exposed cohort, compared to the general population of junior doctors and medical students, and yet there are marked differences among individuals in the content, duration and intensity of IR undergraduate education. IR teaching models from modular to integrated designs have been proposed to locally adapt the published undergraduate curricula [3, 6, 13, 14] but more consistent implementations at the national level are still required. Inadequate undergraduate curricula and heterogeneous individual experience are likely contributors to the small proportion who only come across IR during their postgraduate training. However, not having an early interest in IR during medical school does not preclude individuals from pursuing IR from a later stage – junior doctors remain important potential candidates.

The study also highlights that the current level of extra-curricular exposure is insufficient. Considering these self-selected subjects are exceptionally motivated, the study shows that they are not well informed. One third and three quarters have not engaged with BSIR or CIRSE (nor their junior programmes), respectively. Very few are aware of published IR medical student curricula either. This demonstrates the need for continuous efforts and more innovative approaches to reach out to those potentially impressionable but unaware or less exposed, and to provide information and opportunities to those already interested and motivated. Indeed, most attendees expressed interest in a portal website dedicated to IR-related events and resources, which is subsequently realised via the IRJuniors.com. This non-profit website attracted approximately 1800 visits and 400 subscribers between December 2019 and February 2020 [15]. Social media, particularly Twitter, has been shown to effectively generate user engagement among IRs [16] and can be utilised as an accessible and cost-friendly outreach platform. It can also be a useful tool to widen IR engagement and increase IR awareness among the patients, general public and IR referrers (e.g. general practitioners) which was historically poor [17, 18, 19]. Raising the profile of IR specialty among both medical professionals and general public can potentially generate a positive flow-on effect for future trainee recruitment. In addition to online resources, leadership roles within the junior committees of professional organisations remain a more traditional and effective approach to nurture aspiring individuals to become IR advocates. A few of the BSIR Trainee Committee members have demonstrated exceptional initiatives when organising the abovementioned IR events, establishing IR student societies in universities, and promoting other forms of IR-education at both undergraduate and postgraduate levels. Also, one of the largest student engagement programmes ‘Be inspIRed’ during CIRSE annual meetings since 2010 is organised by enthusiastic radiology trainees from all over Europe collaborating under the European Trainee Forum of CIRSE.

The study also shows that symposia is a useful way to present the specialty, provide career insights and trigger interest in a relaxed, face-to-face and interactive environment. With support from enthusiastic IRs, the BSIR and respective medical schools, these five events demonstrate high quality engagement and positive recruitment effects on all stages of trainees. It should also be recognised, however, that not all attendees would become IRs. Indeed, some may become knowledgeable future referrers with whom stronger interdisciplinary collaborations can be formed. Nevertheless, a large pool of motivated and informed candidates is ultimately helpful to resolve the workforce shortage.

This study has several limitations. The subjects sampled are a more motivated cohort and therefore not representative of the general population of junior doctors and medical students, resulting in a selection bias. The survey is cross-sectional and it is therefore not possible to determine the long-term effects of IR exposure on individuals' eventual career choices. Also, the answers for survey questions are based on retrospective recall so the study is inevitably affected by reporting biases.

Conclusion

Involvement with IR clinical activities is the most important contributor to an individual's positive view towards an IR career. IR-related elective modules, portfolio building, and junior committee roles with professional organisations are important for the more motivated. IRs should continue investing time supervising junior doctors and medical students in clinical and non-clinical domains while advocating to increase IR representation in undergraduate curricula. High-quality symposia are effective in providing specialty and career information in extra-curricular settings. Actively inspiring and recruiting junior doctors and medical students at all stages are key to generate informed and motivated candidates for the future of IR.

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