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RESEARCH

# Continuing dental education in radiation protection: monitoring the outcomes

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**Objectives:** To evaluate an evolving radiation protection dental postgraduate course run in Wales between 2003 and 2007.
**Methods:** We compared three standardized course series. Course content was enhanced in 2006 to target areas of weakness. In 2007, a single best answer multiple choice questionnaire instrument superseded a true/false format. Practitioners' performance was studied pre- and immediately post-training. 900 participants completed identical pre- and post-course validated multiple choice questionnaires. 809 (90%) paired morning–afternoon records, including those of 52 dental care professionals (DCPs), were analysed.
**Results:** Mean (standard error) pre- and post-course percentage scores for the three courses were 33.8 (0.9), 35.4 (1.4), 34.6 (1.0) and 63.6 (0.9), 59.0 (1.4), 69.5 (0.9). Pre-training, only 2.4%, 3.1% and 4.9% of participants achieved the pass mark compared to 57.7%, 48.4% and 65.9% post-training, indicating a rather greater pass rate and gain in the most recent series than earlier ones. In recent series, older more experienced candidates scored slightly higher; however, their gain from pre- to post-training was slightly less.
**Conclusions:** Baseline levels of radiation protection knowledge remained very low but attending an approved course improved this considerably. Targeting areas of weaknesses produced higher scores. Current radiation protection courses may not be optimal for DCPs.
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**Keywords:** education, radiation protection

## Introduction

Continuing professional education (CPE) is recognized as a prerequisite to the maintenance of standards of professional practice, especially in the health professions. It involves a considerable outlay of both course attendees' and providers' time, as well as considerable financial cost regardless of how it is funded. Evidence for the effectiveness of CPE programmes and interventions is limited, and what evidence is available suggests that the effectiveness is far from optimal. Accordingly, there is the need both to develop improved methods of CPE and to demonstrate that there are indeed improvements. Furthermore, the context in which CPE is given is a rapidly changing one, involving advanced technologies, teaching techniques and materials, and above all new statutory and professional regulations and altering patient expectations. The education system must respond to these changes in a timely manner, in line with needs assessment and outcome evaluation.[1]

The subject of radiation protection and safety has, deservedly, a high profile in society. Developing public awareness and concern over the possible hazards of radiation has led to the reappraisal of many aspects of radiation protection. In the UK there are two sets of statutory regulations (Ionising Radiations Regulations (IRR) 1999 and Ionising Radiation (Medical Exposure) Regulations (IRMER) 2000 governing the use of ionizing radiation.[2,3] These concern the safety of health workers, patients and the wider public and are consistent with the Directives of the European Community.[4,5]

Dental radiographic examinations still represent the most frequently undertaken radiological investigations

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in the UK. A recent survey conducted by the National Radiological Protection Board (NRPB) demonstrated that dental X-rays amounted to about 10 000 000 intraoral and 3 330 000 panoramic radiographs per year, constituting approximately one-third of all medical X-ray examinations.[6] The same survey also concluded that although the yearly effective dose has not changed in the last decade, CT imaging has more than doubled its contribution and is now responsible for 40% of the total dose to the population from clinical X-rays. These high-dose procedures apply also to dentistry where modern CT imaging for implantology and maxillofacial surgery is becoming more readily available. Therefore, optimization and dose reduction in this field are a priority.

In 2002, the UK General Dental Council (GDC) introduced compulsory continuing professional development (CPD) to protect patients and maintain public confidence in the dental profession. This is designed to ensure and confirm that dentists keep up to date, so that they give their patients the best possible treatment and care. The GDC also sets standards and assures quality of dental education. It recently revised its guidance regarding verifiable CPD and identified three subject areas that all dentists should cover as part of the overall 75-hour minimum requirement.[7] These include radiography and radiation protection, which has thus become an important component of the revalidation scheme.

In our previous publications on the effectiveness of dental postgraduate courses in radiation protection, we assessed the attendees' level of knowledge in this area both before and immediately after training using identical multiple choice questionnaire (MCQ) instruments.[8,9] Prior to attending these courses, the level of knowledge was very low. Furthermore, whilst attending the approved course led to considerable improvement, it did not invariably result in a satisfactory level of knowledge, in particular in radiation physics and statutory regulations. The prescribed standard was achieved by less than 60% of the attendees. We continued to monitor the effectiveness and outcomes of the IRMER courses in two further series of course attendees following some changes to our teaching programme. In 2006 we modified our teaching to place greater emphasis on the areas of weaknesses found in the previous study, while continuing to use a true/false (TF) MCQ instrument to assess attendees' knowledge before and after instruction. In 2007 we used the same teaching as in 2006, but changed the test instrument to a single best answer (SBA) format, using questions presenting five choices, as recommended by some educationalists.[10] The authors believe that this type of research can provide information useful to the development of future postgraduate courses, teaching methods and resources, and CPD in general.

Therefore, the objectives of this study were:

1. to evaluate the immediate outcomes of the IRMER courses run in Wales in 2007 (third series)
2. to compare the results with those of the first (2003–04)[9] and second (2006) series.

## Materials and methods

We report and compare results for three series of participants in standardized 1-day CPD courses which were run in several centres in Wales in February and March and delivered by the same specialist teachers. Following an informed consent, each participant completed a validated MCQ test instrument before the teaching session and an identical one at the end. These were completed anonymously and linked using participant identifying numbers. The attendees' year and place of graduation together with their positions were recorded. All analyses were based on participants with matched AM (pre-training) and PM (post-training) data only. The characteristics of the three series are summarized in Table 1.

Series 1, reported elsewhere, comprises 253 dental practitioners attending courses run 8 times in 6 centres in Spring 2003 and 2004.[9] The test instrument used consisted of 80 TF items and is scored with negative marking.

Series 2 comprised 128 general dental practitioners attending courses run in 4 centres in Spring 2006. The teaching was enhanced as described earlier, but the same TF MCQ test instrument was used as in Series 1.

Series 3 comprised 376 dental practitioners and 52 dental care professionals, who attended courses run in 3 centres in Spring 2007. Teaching was as in 2006, but an SBA MCQ test instrument was used, consisting of 16 questions with 5 options each. The participant is instructed to choose the best answer, so the range of possible scores is from 0 to 16.

## Standardization of scores and statistical analysis

For the TF MCQ results obtained in Series 1 and 2, the range of possible scores was −80 to +80. Accordingly,

**Table 1** Characteristics of the three series of course participants

| *Series* | *Total participants* | *Training method* | *Assessment method* | *Number of questions* | *Mark expected by chance guessing (%)* |
|---|---|---|---|---|---|
| 2003–04 | 253 | Old | True/false MCQ | 80 | 0 |
| 2006 | 128 | New | True/false MCQ | 80 | 0 |
| 2007 | 428 | New | Single best answer MCQ | 16 | 20 |

MCQ, multiple choice questionnaire

scores are expressed as percentages of the maximum available, *viz.* 80. The resulting percentage scores can theoretically range from −100% to +100%, with chance guessing resulting in an expected score of zero. As in our previous report,[9] we regarded scores of 50 out of 80 (62.5%) or above as satisfactory.

Likewise, the SBA results in Series 3 may be expressed crudely as percentages of the maximum score available, here 16. However, as there is no negative marking, random guessing would be expected to lead to a mark of approximately 20% of 16 or 3.2. With this in mind, it was generally more appropriate to report adjusted percentage scores which are obtained by subtracting 3.2, then divide by 16 – 3.2 = 12.8 and finally convert to a percentage. The resulting adjusted percentage score can range from −25% to +100%, with a score of zero again corresponding to chance guessing. For the SBA instrument, after considering several options and bearing in mind the inherent differences between the two instruments, we chose to regard a score of 12 out of 16 or above as satisfactory, corresponding to a crude score of 75% or an adjusted score of 68.75%.

Confidence intervals (CIs) for the change from baseline to post-course assessment in the proportion of participants reaching the specified standard were calculated using previously described methods.[11] Changes in score from baseline to post-course assessment were compared between position and place of graduation groups by analysis of covariance (ANCOVA). Correlations reported are parametric (Pearson) or non-parametric (Spearman) according to distributional form.

## Results

Table 2 shows summary statistics for pre- and post-course adjusted percentage scores for the 2007 Series 3. At baseline only 21 (4.9%) of 428 practitioners achieved the chosen standard of 12 out of 16. After the course, 282 (65.9%) did so, an improvement of 61.0% (95% CI 56.1% to 65.4%).[11]

Table 3 shows numbers of participants according to their position and place of graduation. Figure 1 compares mean adjusted percentage scores pre-training, post-training, and improvement between these groups. Before training, hospital dentists tend to have the highest scores and dental care professionals (DCPs) the lowest, although the difference between the five groups is not statistically significant ($P = 0.12$). After training there are significant differences ($P = 0.013$), with community dentists achieving the highest scores and DCPs the lowest. ANCOVA showed that, when baseline differences are taken into account in the most appropriate way, differences between groups post-training approach statistical significance ($P = 0.056$), with community dentists achieving the highest improvement in score and DCPs the lowest.

Figure 2 shows the effect of place of graduation. Both pre- and post-training, scores differed highly significantly between groups, with London graduates highest and overseas lowest. Using ANCOVA, changes from baseline to post-training scores differed significantly ($P = 0.030$), with overseas-trained candidates showing the least benefit.

Years of graduation for the 2007 participants ranged widely from 1954 to 2007, with a negatively skewed distribution with mean 1990, median 1992, standard deviation (SD) 11 years. Using non-parametric (Spearman) correlations, year of graduation was very weakly negatively correlated with AM ($r_S = -0.08$), (95% CI −0.18 to +0.01) and PM ($r_S = -0.04$), (95% CI −0.14 to +0.05) scores, implying that older candidates scored slightly higher at both assessments. Conversely, their gain from pre- to post-training was slightly less ($r_S = +0.06$), (CI −0.04 to +0.15) than for the more recently trained. None of these correlations reaches statistical significance.

The correlation between pre- and post-training scores was large and positive in Series 3 (Pearson $r = +0.52$, Figure 3), in line with expectation and with corresponding results in Series 1 ($r = +0.66$) and 2 ($r = +0.73$). This scatter diagram, with a superimposed diagonal line of identity, represents a summary of the results. It demonstrates that nearly but not quite all candidates showed an improvement in score. The degree of improvement varied greatly between candidates with a positive pre–post correlation but a negative correlation of change with baseline value.

Figure 4 summarises mean adjusted percentage scores pre- and post-training and improvements following training for the eight sections/topics of the radiation protection syllabus for Series 3.

### *Comparisons between series*

Tables 4 and 5 summarise and compare the pre- and post-training scores for the three series. Standard errors are shown in Table 4, to enable informal appraisal of differences. While the improvement in score on training

**Table 2** Summary statistics for pre- and post-course adjusted percentage scores, based on 428 participants in Series 3 (2007)

| | *Mean %* | *SD* | *Median* | *Minimum* | *Maximum* |
|---|---|---|---|---|---|
| Pre-course | 34.6 | 19.8 | 37.5 | −25.0 | 92.2 |
| Post-course | 69.5 | 18.6 | 76.6 | 6.3 | 100 |
| Change | 34.9 | 18.8 | 31.3 | −31.3 | 85.9 |

SD, standard deviation

**Table 3** 428 participants in Series 3 (2007) by position and place of graduation

| *Position* | n | *Place of graduation* | n |
|---|---|---|---|
| GDP principal | 165 | Cardiff | 207 |
| GDP assistant/ associate | 169 | London | 41 |
| Hospital | 18 | Other British Isles | 119 |
| Community | 24 | Overseas | 61 |
| Dental care professional | 52 | | |

GDP, general dental practice

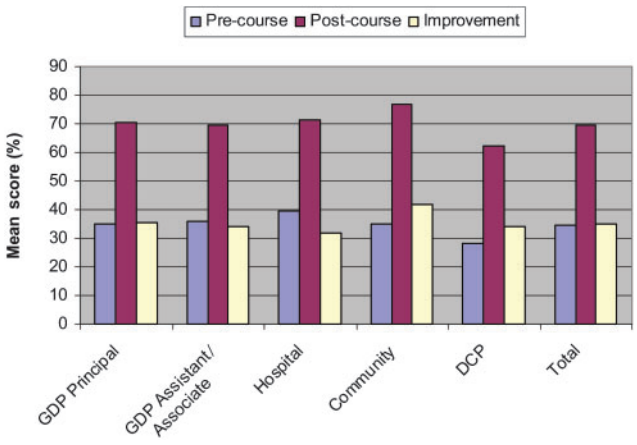


**Figure 1** Comparison of results in Series 3 (2007) according to position of practitioner. DCP, dental care professional; GDP, general dental practice

was apparently weaker in 2006 than in 2003–04, this was not the case in 2007, when the same training method was used but with a different assessment instrument, whether we choose to use crude or adjusted SBA scores. Similarly, in Table 5 the improvement in proportion passing was greater in 2007 than in 2003–04, regardless of which threshold is chosen.

Figure 5a,b shows mean pre- and post-training scores by subject area for the three series. Figure 5c shows mean changes in score from pre- to post-training by subject area for the three series. Results shown for Series 3 are adjusted percentage scores.

## Discussion

The purpose of continuing medical education is the improvement of services to patients. The refreshment of professional enthusiasm that comes from interacting with colleagues and encouraging new ideas is only a means to that end, albeit worthwhile in itself. Section 63 in England (Section 2 in Wales) and the postgraduate allowance both emphasise process rather than outcome, largely because it is easier to measure and less dependent on pre-training characteristics.[12] The current

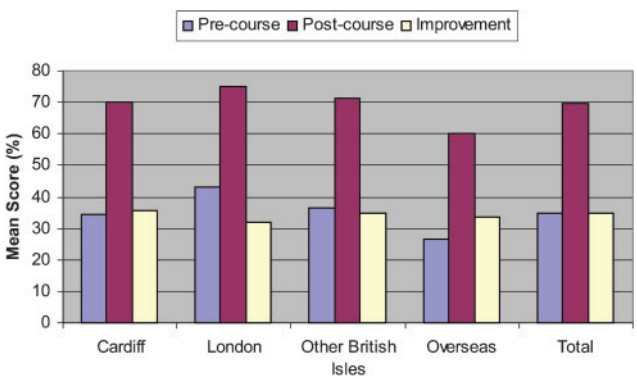


**Figure 2** Comparison of results in Series 3 (2007) according to place of graduation

study measured the outcome in terms of comprehension and knowledge application of the learner gained immediately following the 1-day instruction courses. It does not, however, measure competency and performance. These require more rigorous forms of assessment, such as practice visits and peer review, that have proved too costly to introduce widely.[13] Nor does it measure long-term retention of knowledge gained.

One of the main aims in evaluating and monitoring the effectiveness of educational programmes is to identify the participants' areas of strength and weakness, and to refine both the teaching and assessment methods. Furthermore, as in our previous studies we were interested in performance across a wide range of topics to cover both the subject and the requirements as laid down in the current guidelines.[8,9]

In the 2007 series single best answer items were used instead of TF questions, in line with recommendations by some educationalists as being less ambiguous.[10] The final column in Table 1 indicates the mark that would be expected based on pure guesswork. For the previous sittings which used TF MCQs with negative marking, the chance expected mark would be zero, regardless of whether all or only some questions are attempted. For the most recent course, an important consequence of the single best answer format, with no negative marking, is that a candidate who answers all questions by purely random guessing would be expected to score 20%. In other words, the baseline is no longer 0%, but 20%. For a candidate who fails to answer all questions, the expected mark would be commensurately lower, but in fact failure to attempt all questions did not occur in our series.

In the two previous series, we regarded 50 out of 80 (62.5%) or higher as a pass mark. For the 2007 series, in which pure guessing would lead to a mark around 20%, the pass mark should undoubtedly be set higher. The question is, how much higher? Taking account of the 20% mark expected by guessing, the closest equivalent would be 70%, or 11.2 out of 16, which is of course intermediate between two achievable marks. We therefore examined the effect of dichotomizing AM and PM scores using pass thresholds at 10, 11 or 12 out of 16. If we regard any mark of 10 (62.5%) out of 16 or higher as a pass, then 103 (24.1%) out of 428 of candidates are regarded as meeting the standard before training. After training, this figure rises to 362 (84.6%) out of 428. If we raise the pass mark to 11 (68.75%) out of 16, the numbers passing pre- and post-training decrease to 57 (13.3%) and 334 (78.0%), respectively. We chose to raise the pass mark further to 12 (75%) out of 16 in order to reflect both the high standard required and the nature/style of questions asked. Accordingly, the numbers passing pre- and post-training in Series 3 decreased further to 21 (4.9%) and 282 (65.9%), respectively.

The drive to identify less costly ways of delivering care while maintaining quality is the need to match staff skills to the task and to emerging technology. This has already led to changes in professional roles and

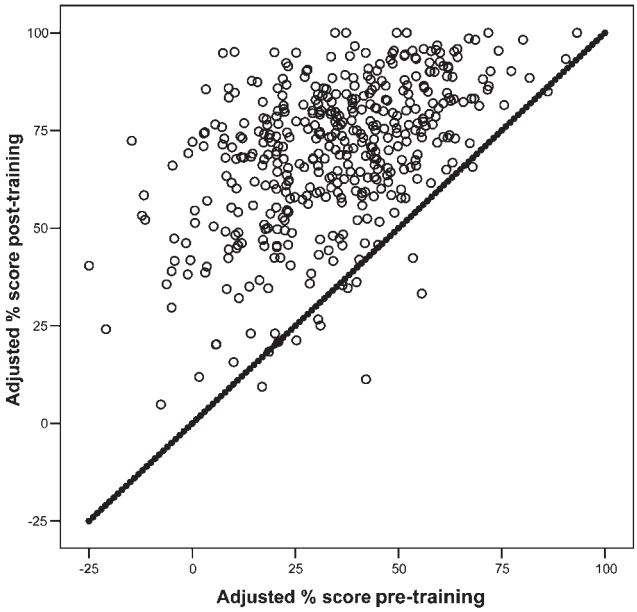


**Figure 3** Relationship between pre-and post-course adjusted percentage scores, Series 3

boundaries both within the medical profession and between health professionals such as DCPs.[1] This latter group was included in the courses run in 2007 as part of the concept of "teamwork" education. The fact that improvements following training were least marked for the DCPs raises the question of the appropriateness of these IRMER courses for them and whether specially designed, possibly self-directed, courses may be more suitable. This is perhaps due to the different educational background and the level at which the information has been communicated.

In the recent series, older more experienced candidates scored slightly higher. Conversely, their gain from pre- to post-training was slightly less than for the more recently qualified. This may be explained by the changing nature of more modern dental curriculae where extra emphasis is made on the subject. In considering the place of graduation, Cardiff attendees

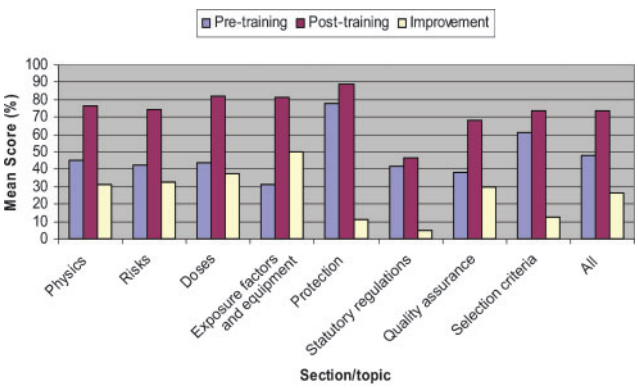


**Figure 4** Change in percentage score from pre- to post-training in 428 attendees of the IRMER courses in 2007, by section of syllabus

**Table 4** Means and standard errors for pre- and post-training scores for the three series

| | | | *Pre-training* | | *Post-training* | | *Increase* | |
|---|---|---|---|---|---|---|---|---|
| *Year(s)* | n | *Rescaling* | *Mean* | *SE* | *Mean* | *SE* | *Mean* | *SE* |
| 2007 | 428 | Crude | 47.7 | 0.8 | 75.6 | 0.7 | 27.9 | 0.7 |
| | 428 | Adjusted | 34.6 | 1.0 | 69.5 | 0.9 | 34.9 | 0.9 |
| 2006 | 128 | | 35.4 | 1.4 | 59.0 | 1.4 | 23.7 | 1.0 |
| 2003–04 | 253 | | 33.8 | 0.9 | 63.6 | 0.9 | 29.8 | 0.7 |

SE, standard error

scored similarly to the total average. However, the overall score may have been slightly reduced due to the high proportion of DCPs (56%) in the Cardiff group.

An attempt to compare results between the 2007 series and the two preceding ones was made. The 2006 results were compared to those obtained in 2003–04 using the same instrument following what we regarded as an improved package of training. The results suggested that the changes were detrimental rather than beneficial. However, the results for 2007, using the same training package but a different assessment instrument, showed the new training in a different perspective. We would certainly no longer want to claim simply that the changes were detrimental rather than beneficial as the 2007 results look very favourable. The limitation of this study is that the overall picture presented by the comparative data is far from clear as a result of using two types of assessment *i.e.* single best answer MCQ and true/false questions. Even rescaling to allow for the expected 20% correct by guessing does not entirely get around the difficulty. However, it does demonstrate the overall trend. Table 4 shows means and standard errors for all our IRMER series. It should be borne in mind that for the 2007 data, purely on account of the way that the adjustments are carried out, the adjusted means pre- and post-training are lower than the crude ones, whereas the change in the adjusted percentage score is greater than that in the crude percentage score, as are all the standard errors.

Similarly, it is clear that a pass mark of 10 out of 16 leads to results very different to those of previous sittings. Setting the pass mark at 12 out of 16 gives a proportion passing at baseline that is broadly comparable with that for previous sittings and still suggests a post-training pass rate superior to what we achieved before, which is extremely reassuring.

At baseline, the level of knowledge was low in the three series. However, in the 2007 series, the lowest scores related to exposure factors and equipment and quality assurance (31.1% and 38.3%, respectively). These improved substantially by 49.9% and 29.9%. Statutory regulations was the only topic where the score started relatively low and ended with only a 4.6% improvement. This means that in monitoring the outcome of postgraduate courses, targeting areas of weakness can yield higher scores and more satisfactory results. This was clearly demonstrated in Figure 5c where the line diagram shows the reversed pattern of

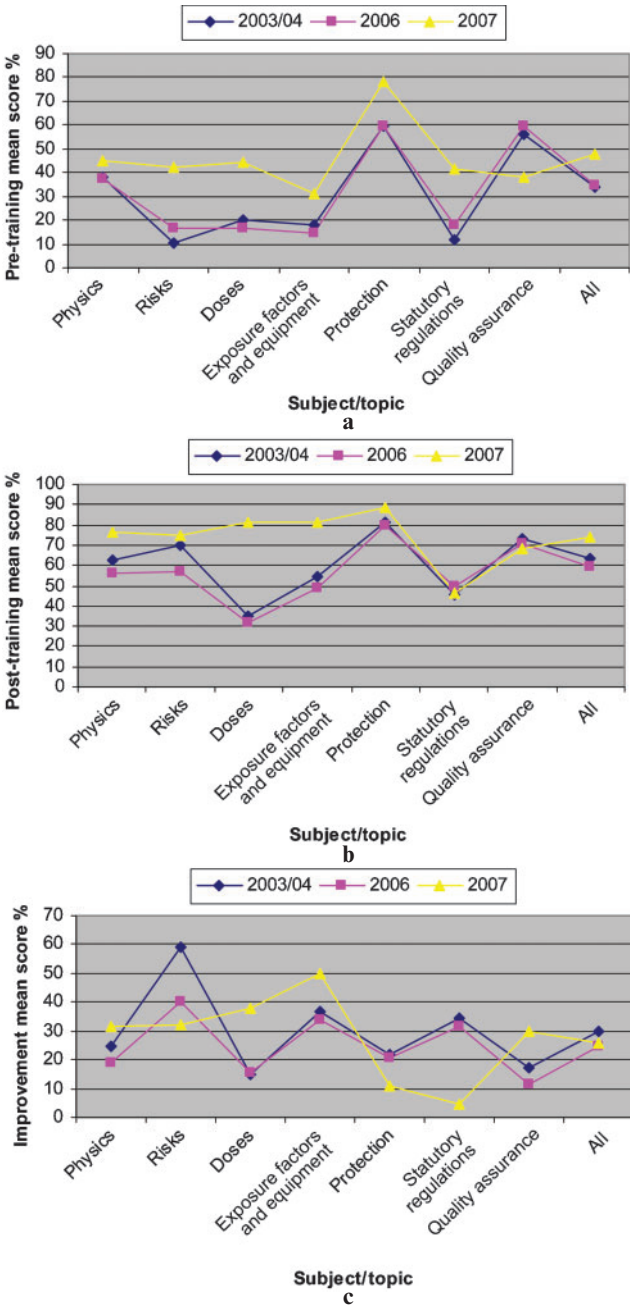


**Figure 5** (a) Mean pre-training score by subject area for the three series. (b) Mean post-training score by subject area for the three series. (c) Mean change in score from pre- to post-training by subject area for the three series.

improvement for the three series. If this strategy was adopted in similar postgraduate courses, it is likely that education providers, attendees and the public would benefit from the higher professional standards.

In conclusion, postgraduate courses emphasise process rather than outcome, largely because it is easier to measure and are less dependent on pre-training characteristics. This study measures the outcome in terms of comprehension, knowledge and trends. It does not, however, measure competency and performance nor long-term retention of knowledge gained. In addition, the level of knowledge in radiation protection was very low at baseline and attending an approved course improved this considerably. The results indicate that current IRMER courses may not be suitable for DCPs and dentists qualified in overseas universities. Furthermore, dentists who qualified in recent years obtained slightly greater benefit from the course and targeting areas of weaknesses resulted in higher scores. The pass rate for IRMER course in 2007 was higher than that of 2003/04.

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**Table 5** Proportions of participants attaining chosen standards pre- and post-training for the three series

| | | | *Percentage of participants achieving pass mark* | | | |
|---|---|---|---|---|---|---|
| *Year(s)* | n | *Pass mark* | *Pre-training* | *Post-training* | *Change* | *95% CI* [10] |
| 2007 | 428 | 10/16 (62.5%) | 24.1 | 84.6 | 60.5 | 55.4–64.9 |
| | | 11/16 (68.8%) | 13.3 | 78.0 | 64.7 | 59.8–68.9 |
| | | 12/16 (75%) | 4.9 | 65.9 | 61.0 | 56.1–65.4 |
| 2006 | 128 | 50/80 (62.5%) | 3.1 | 48.4 | 45.3 | 36.2–53.8 |
| 2003–04 | 253 | 50/80 (62.5%) | 2.4 | 57.7 | 55.3 | 48.9–61.3 |

CI, confidence interval

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