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Memorandum

Developing the radiation protection safety culture in the UK

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Abstract

In the UK, as elsewhere, there is potential to improve how radiological challenges are addressed through improvement in, or development of, a strong radiation protection (RP) safety culture. In preliminary work in the UK, two areas have been identified as having a strong influence on UK society: the healthcare and nuclear industry sectors. Each has specific challenges, but with many overlapping common factors. Other sectors will benefit from further consideration.

In order to make meaningful comparisons between these two principal sectors, this paper is primarily concerned with cultural aspects of RP in the working environment and occupational exposures rather than patient doses.

The healthcare sector delivers a large collective dose to patients each year, particularly for diagnostic purposes, which continues to increase. Although patient dose is not the focus, it must be recognised that collective patient dose is inevitably linked to collective occupational exposure, especially in interventional procedures.

The nuclear industry faces major challenges as work moves from operations to decommissioning on many sites. This involves restarting work in the plants responsible for the much higher radiation doses of the 1960/70s, but also performing tasks that are considerably more difficult and hazardous than those original performed in these plants.

Factors which influence RP safety culture in the workplace are examined, and proposals are considered for a series of actions that may lead to an improvement in RP culture with an associated reduction in dose in many work areas. These actions include methods to improve knowledge and awareness of radiation safety, plus ways to influence management and colleagues in the workplace. The exchange of knowledge about safety culture between the nuclear industry and medical areas may act to develop RP culture in both sectors, and have a wider impact in other sectors where exposures to ionising radiations can occur.

Keywords: radiation, protection, culture, nuclear, healthcare, medical

(Some figures may appear in colour only in the online journal)

1. Introduction

At the IRPA12 Associate Societies Forum in Buenos Aires in 2008, the French Society for Radiation Protection (SFRP) proposed to launch an IRPA initiative for enhancing radiation protection (RP) culture among the RP professionals worldwide. This proposal was favourably received by the participating Associate Societies, and the IRPA Executive Council decided to actively support this initiative. IRPA started to develop a document on IRPA Guiding Principles for Establishing a Radiation Protection Culture, which will be published in Spring 2014. In the UK, SRP and its Partner Societies (see appendix) established a Working Group with the objectives of:

- Feeding into the development of the IRPA guidance document, and
- Developing a work programme to develop UK guidance to help equip radiation protection professionals to promote a successful RP culture in their workplace.

SRP held an initial workshop of professionals from the nuclear industry and medical sectors (including members of its partner societies in the medical field) in the autumn of 2011 to seek to identify the key issues and to map a route forward. The workshop identified ideas and suggested actions relevant to the medical and nuclear industry sectors. However, many of the suggested actions are generic and are therefore potentially beneficial to other sectors not directly represented at the meeting, such as universities and general industry.

The interim output from the SRP Working Group was presented at the IRPA13 International Congress in Glasgow in 2012 (Hallard *et al* 2012); as was an early draft of the IRPA guidance (IRPA 2013). One conclusion of the IRPA13 Congress was 'Further development and

dissemination of the RP culture is still necessary among professionals and the public due to an increase of risk awareness, the constant development of scientific knowledge, a decreasing number of RP professionals, and the introduction of new exposure situations'. Subsequently IRPA identified that RP Culture will be a major thread in IRPA14 in Cape Town and intervening Regional Congresses.

SRP and its Partner Societies have continued to contribute to the Draft IRPA Principles Document and are now looking to take forward the development of UK guidance and its practical implementation. As part of this process, it was felt it would be useful to publish the current output of the SRP Working Group and the projected way forward.

As will be deduced from the main text, RP Culture is not an exact science; it is more of an art, with the RP professionals playing a crucial role in its acceptance and implementation. As such there is often limited documentary evidence to base assessments on. It is recognised that in this paper a number of judgments are made, based on the collective experience of the authors. One of the challenges in the journey of the way forward will be to develop ways of refining such judgments.

2. Overview

The importance of a strong radiation safety culture for reducing doses to as low as reasonably practicable (ALARP) and preventing the occurrence of radiation incidents is hard to overstate. Safety Culture is at the root of all our behaviour in the workplace. A good safety culture in an organisation will manifest itself as all employees striving to adopt safe behaviour and prevent harm to colleagues simply because that 'is the way we do things here'.

Achieving this is a challenging task. The pressures of cost and productivity, essential to the survival of a business or the delivery of high quality healthcare, often appear to compete with the desire for high levels of safety. Yet experience shows that far from being in competition, good safety culture and good, cost effective performance and customer care are complementary. The same priorities and patterns of behaviour inherent in a good safety culture also support high quality operations and productivity.

This paper discusses the features common to a good safety culture in the radiation protection context, and proposes means to assist improvement. It should be added that overconfidence and denial of the need to improve is often a symptom of a declining safety culture—we all have the need to improve our safety culture whatever the starting point.

In the area of RP safety culture, two areas have significant importance due to their impact on actual and potential doses to employees and the public; the medical and nuclear industry sectors. The two sectors are obviously very different in scope and purpose, and will display the influences of safety culture in different ways. However, in terms of behaviour and outcomes, a number of features are common to a good safety culture in any organisation.

RP culture is effectively a sub-set of the wider safety culture, and it must integrate with these wider cultural considerations in any workplace. It is particularly important that RP culture considerations do not start from a blank sheet of paper—almost all of the thoughts already developed on nuclear safety or process safety culture are directly relevant to RP culture. In particular, the authors were attracted to the views on 'Nuclear Safety Culture' expressed by the Institute of Nuclear Power Operations (INPO), the US Nuclear Regulatory Commission (NRC) and in the IAEA International Nuclear Safety Advisory Group (INSAG-4 and 15) reports (IAEA 1991, 2002, INPO 2004, NRC 2010).

Some of the key features of a strong safety culture are listed below;

- Everyone is personally responsible for safety
- Leaders demonstrate commitment to safety
- Trust permeates the organisation
- Decision-making reflects safety first
- A questioning attitude is cultivated, including challenge of potentially unsafe acts and decisions at all levels of an organisation without deference to seniority
- Open reporting of problems and errors, including admission of error without the allocation of blame
- Organisational learning is embraced
- Employer involvement at all levels in improving safety and performance
- Safety undergoes constant examination
- And, usually, good operational performance

The Society for Radiological Protection (SRP) has sponsored work to seek practical methods and ideas to assist improvement in safety culture in the workplace of the medical and nuclear industry sectors which is summarised in this paper. Although these areas are addressed specifically due to their significance in UK society, the issues are often generic and transferrable to other fields.

3. Background of the nuclear and medical sectors

It is acknowledged that exposure in the medical sector falls into two clearly different categories: (a) patient exposure, and (b) occupational exposure. This paper focuses on occupational exposure in these sectors. Nevertheless, it is noted that improvements in radiation protection culture may have beneficial effects in reducing both staff and patient doses in the medical sector, though not necessarily proportionately.

In the medical sector, where patient care is the overall aim of healthcare professionals, it's not surprising that radiation protection has a significant focus on the patient. Guidance on the control of patient exposure is generally well developed and in many cases is proactively implemented. However many professions can be involved, from the requesting of an examination, through its execution and reporting on to its availability to clinicians in the future. RP culture will need to encompass all these areas and there will undoubtedly be scope for improvement. Similarly there could be scope to improve the culture associated with the protection of healthcare staff from radiation exposure.

The radiation hazard in the medical sector has some different characteristics from that in the nuclear industry. In contrast to the nuclear industry, most potential staff exposure in the medical sector originates from x-ray machines (either as main beams or scattered radiation from patients) which, for short periods of time, can produce much higher dose-rates than those associated with radioactive materials or waste. In addition, in the medical sector there are far more people than in the nuclear industry employed in work directly with sources of ionising radiation or who may be potentially exposed to ionising radiation in the course of their duties.

Nevertheless, it is arguable that the collective radiation hazard to UK workers in the medical sector is largely similar in magnitude to that from UK nuclear industry. In 2005, the then Health Protection Agency (HPA—now Public Health England) reported that the annual collective occupational dose in the UK nuclear industry was 14.6 man Sv whereas that from medical occupational exposure (including dental and veterinary) was 10.2 man Sv (Watson *et al* 2005).

In the UK there are a significant number of medical procedures carried out each year that use ionising radiation and the frequency of such procedures appears to be increasing. A study by the HPA in the UK published in 2010 (Hart *et al* 2010) has estimated that about 46 million medical and dental x-ray examinations were carried out across the UK in 2008, which is an increase of 10% since 1997. Approximately two-thirds of the procedures were carried out in NHS hospitals whilst one quarter was performed by dentists. The HPA study reveals that the average annual radiation dose to each member of the public from all diagnostic x-rays has increased by about 20% from 0.33 mSv in 1997 to 0.4 mSv in 2008. Most of this increase is due to the growth in the number of computed tomography (CT) examinations which generally deliver a higher radiation dose than conventional x-ray examinations. About 1.4 million CT scans were performed in the UK 1997 and 3.4 million in 2008—a rise of 140%. The NHS Breast Screening Programme accounted for 2.03 million x-ray mammography examinations in 2008, an increase of 45% since 1997. About 1.2 million x-ray examinations were taken in independent hospitals in 2008, a rise of 40% since 1997. In the light of these figures, it would not be surprising if the limited resources available for radiation protection are allocated with priority to patient protection in the face of an ever increasing staff workload.

The aims of the nuclear sector—the on-going production of power for the country, together with defence and legacy issues—are totally different from those of the medical sector—the prevention of death and/or the improvement of life quality—and it must be recognised that these may lead to a different mind-set in the workplace. Nonetheless, it is the perception of the authors that the medical sector potentially has a poorer level of radiation safety culture than that in the nuclear sector. Indeed, there exists, perhaps, an opportunity for the UK medical sector to learn some lessons from the nuclear industry about radiation safety culture and methods for improving it. In the authors' experience, the radiation workers' views on health physics support are different in these two major sectors. In the nuclear sector, workers accept that health physics support, and often approval, is vital to the successful planning and completion of their tasks. Whereas in the healthcare sector, staff often perceive that the 'health physicist' is an obstruction to their tasks. There is a need for better knowledge organisation-wide of each other's roles and aims and pressures, and an appreciation that working together can only act to improve radiation protection culture.

The issues in the UK nuclear industry are very different but no less important to those in the medical sector. In general, the operations at most UK sites can be split into two activities—operation of current facilities and decommissioning of redundant facilities. However, in the forthcoming years we may see the construction of new nuclear power facilities or long-term radioactive waste repositories.

Radiation doses from operating facilities in the nuclear industry have dropped dramatically from the high levels seen in some sites in the 1960s and 1970s (Watson *et al* 2005). In the main, this is due to significantly improved design of plant and better dose control arrangements. While the need to optimise dose must always continue, the priority for the allocation of limited funding is clearly likely to be low where doses are already below 1 mSv $year^{-1}$.

However, the growth in the decommissioning of redundant facilities poses a far greater challenge to both radiation dose levels and avoidance of accidents. Many of these redundant facilities were designed in the 1950s and 60s with limited technology and in some cases with a strong military input to the operating priorities. Decommissioning in these areas involves not only restarting work in the facilities responsible for the very high radiation doses on some sites in the 1970s, but often doing work which is more difficult than those original operations. Examples include the dismantling of gamma caves, alpha glove-box

cells and the emptying of redundant, and often very contaminated, fuel storage ponds and waste silos. The difficulties inherent in this decommissioning work have led to a significant split in typical radiation doses between those involved in current operations with low doses and those involved in decommissioning operations with significantly higher doses. Radiation doses close to 10 mSv $year^{-1}$ can be seen in the most challenging facilities. There have also been a number of incidents involving additional radiation dose to workers, breaches of Regulations and impact on plant. This has inevitably had an impact on public confidence in the nuclear industry.

Against this very challenging background, avoidance of unnecessarily high radiation doses and incidents can only be achieved with a strong safety culture displaying all of the features listed in the introduction of this paper.

4. Analysis of the issues: factors common to all areas

It is believed that there are a number of common issues or factors which can influence and even limit the development of a strong safety culture.

5. Management and leadership

Decisions or actions that lead to negative radiation protection consequences are often made with the best of intentions in order to achieve other objectives important to the organisation or person making the decision without a clear vision of the total impact. Examples from the nuclear sector might include a requirement to wear radiation protective equipment in areas that do not merit such onerous protective measures slowing down work and counter-productively leading to an increase in external dose, and routine radiological surveys in medium to high dose-rate areas where normal access is minimal. In the medical sector, examples could include repeating x-ray procedures as previous diagnostic data is not readily available, or failure to provide prompt and/or adequate training for all relevant staff in the safety features of a new piece of diagnostic x-ray equipment due other demands on departmental manpower resources.

Trust between senior management and employees is critical to the process of establishing or improving radiation protection and this can be very fragile. Consistent dialogue, openness and the development of common safety goals must be developed and maintained. The fundamental driver and leadership for a strong safety culture must come from the very top of the organisation, but with strong and active support from the rest of the organisation, built on trust.

Management at all levels must believe in the process of cultural change and be prepared to lead. Mixed messages, inconsistency and a half-hearted approach will very quickly undermine the efforts of the senior team. This means that the process must cascade consistently from all members of the top team and must involve all levels of management. Front line management is particularly important in setting local priorities and standards, so failure to engage this level of management fully will derail the process.

Direct involvement of the employees themselves working with local change agents (including safety representatives) is essential. Looking out for colleagues practicing unsafe behaviour (consciously or unconsciously) often requires constructive challenge and therefore a great deal of sensitivity, mutual trust and confidence.

Clearly this means that top down messages alone are not sufficient to change culture. The process needs to be planned and implemented as a major strategic priority throughout the organisation.

6. Knowledge of radiation risks and impact

Knowledge and understanding of the real radiation risks relative to their benefits are critical. A significant improvement in awareness and technical knowledge would greatly assist the development of a strong safety culture. In fact, the lack of proper understanding of radiation risks by some key players is considered to be a current major hurdle to establishing an effective radiation protection culture. However, the knowledge needs to be matched to the needs of the organisation and the role of each individual within it. A Board member, a Director or a senior general manager needs a different subset of knowledge compared to a radiographer, a front line worker or a technician. Several of these key roles are not always identified in current training programmes. It is important to identify the key roles involved, the knowledge requirements for each role, and how that knowledge can be effectively imparted.

7. The role of the radiation protection adviser

A key player in developing and embedding a strong workplace radiation protection culture is the Radiation Protection Adviser (some countries refer to this role as the Radiation Protection Expert). However, this is a role that is not well understood in many areas. Amongst radiation protection specialists it is clear that the role is intended to assist the employer to optimise radiological protection and to maintain compliance with the law. However, seen from the perspective of an employer who is under pressure to deliver difficult goals, it can appear that the role is about creating hurdles to getting the job done simply and effectively.

In order to succeed in this difficult task, the RPA has to act as a facilitator and change agent within his or her organisation, working persuasively at all levels from very senior management to the shop floor. The demands of this role require good communication skills, such as persuasive abilities, and many RPAs need help to develop these. In particular, it is important that RPAs learn to speak 'the language of senior management' to facilitate communication on radiation protection matters within the upper echelons of the organisation. The opposite will not happen. Very few relevant training opportunities are normally available to support RPAs in this endeavour. Almost all training and updating facilities available through the SRP and its partner societies are of a more technical nature. Therefore, it is important that SRP and its UK partner societies review how to help RPAs develop these 'soft skills' which are vital to success in driving a successful radiation protection culture.

8. The role of the radiation protection supervisor (RPS)

In the UK, the RPS (referred to in some countries as the Radiation Protection Officer) is usually a front line supervisor who monitors and strives to maintain the radiological safety of teams working with radiation. The RPS has a crucial role in developing and maintaining a strong radiation protection culture. However, the workload of this individual or group is often high, with competing pressures on time and priorities, which can result in operational priorities taking precedence over control of radiation practices. It is important that support is given to this group by employers and professional bodies, e.g. to enable the sharing of experience and good practice and to assist the implementation of simple ways to improve radiological safety procedures (and thereby reduce collective dose) without affecting operational delivery.

9. The role of the professional bodies

Professional bodies (SRP and the partner societies in the UK) have a direct role to play in promoting the development of a strong radiation protection culture. They must take a lead in ensuring that RP practitioners are aware of the importance of cultural issues, and should help to equip them adequately for this task. In many cases, the professional bodies are also in a good position to interact with outside bodies representing key stakeholders to help achieve improved understanding and support. The RPAs and RPSs can then build on this platform within their individual organisation. Specific examples include interactions with key health service groups, nuclear industry safety directors, regulators and other industry groups. Professional bodies should seek opportunities to develop these links.

10. Regulators

The regulators are a critical stakeholder group and individual regulatory inspectors have a powerful opportunity to offer support and encouragement for developing an effective radiation protection culture. Indeed, investment by the regulators in supporting this process is likely to be very cost effective, e.g. in reducing the number of incidents or regulatory infractions that they need to devote effort to. The potential role of senior regulators interacting with the Boards and senior management of organisations can be critical in gaining support from the top. Discussions between the regulators and the professional bodies could serve to actively promote the right conditions and behaviour by all parties for culture development.

11. Learning from experience

The development of a true learning organisation is one major attribute of a good culture. Without it we are destined both to repeat the mistakes of the past and ignore the lessons of past successes. Effective operational experience feedback (OEF) is therefore critical, but can be difficult to achieve. In some environments this is particularly challenging, with local sensitivities over releasing information for wider sharing and learning, and even a perceived risk of prosecution or litigation. Efforts are necessary to encourage the widest and most effective sharing of all learning opportunities.

12. Monitoring cultural developments and/or improvements

Any endeavours for the development and/or improvement of a radiation safety culture need to be monitored in order to demonstrate effectiveness. As such, ‘quantitative measures’ of cultural performance are desirable and might include:

- The collective worker dose per annum within the organisation (or sub-section of the organisation)
- Number of radiation-related incidents or near-misses per annum, and the level of reporting of such events (especially near misses)
- Number of persons proactively attending radiation safety training—this might include refresher training or exam results
- Number of late and non-returned personal dose-meters

It must be acknowledged that no single ‘measurable’ or ‘measurement’ may be sufficient to give a true picture of what is happening with respect to cultural changes within an organisation, and trends in such ‘measurables’ might provide a better assessment. In addition, some

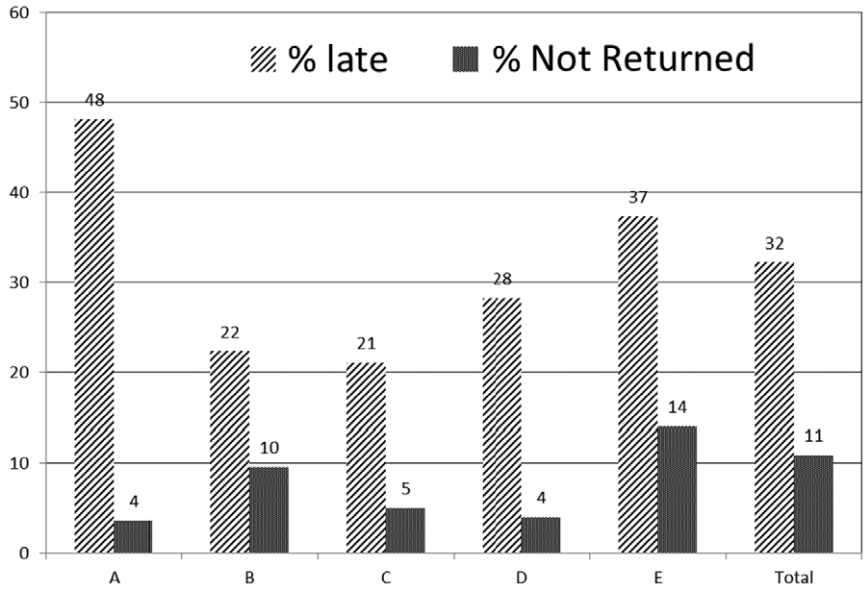

Figure 1. Late and non-returned dose-meters in 2011 from a sample of five UK hospitals A–E.

quantities will be affected by multiple confounders that are not related to culture status such as workload or the application of better resources. To address this mixture of qualitative and quantitative parameters; and perhaps more importantly to provide a focus, there may be value in having structured annual reviews.

As an example, in the medical sector the rate of late and non-returned dose-meters is quite high. Data from a sample of five UK hospitals in 2011 (Marsden 2013) is presented in figure 1 and shows typical rates of 30% late return and 10% non-return of personal dose-meters. In contrast, such rates are insignificant on nuclear sites with the application of systems for dose-meter tracking and the installation of technology that links ingress to or egress from certain work areas to dose-meters. These differences reflect different cultures. Improvements in the medical sector require such issues to be on the management's agenda, with senior staff leading by example and communicating their expectations to other staff. There is no way an employer in the nuclear sector would allow such a high rate of late and non-returns to continue. The regulators can have an impact in achieving this.

13. Specific factors: the medical sector

Although the focus of this paper is occupational rather than patient protection culture, it must be recognised that many measures that can be implemented to reduce collective patient exposure may also be beneficial to reducing collective occupational exposure.

The use of diagnostic methods involving radiation is increasing. This profile is influenced by:

- The availability of diagnostic imaging technology
- Time pressures to create all the possible information in one go
- Obesity, which is on the increase, reduces the effectiveness of less intrusive methods, e.g. ultrasound

- There are indications from the Care Quality Commission (CQC) inspection reports that systems for requesting x-ray examinations are open to misuse (e.g. common logins and non-secure passwords) which in turn may lead to inappropriate requests and consequently increased collective patient dose if such requests are not 'filtered out' effectively by the 'practitioner' or operator in the x-ray department or imaging centre
- The increasingly defensive nature of modern medicine might also increase the number of unnecessary diagnostic procedures

There are many pressures on diagnosing professionals to achieve a high rate of throughput of patients, both from management and patients. This can lead to a professional asking for every diagnostic radiation imaging technique available to make sure that he or she gets all of the necessary information first time round, even if some proves to be duplicated or unnecessary. The alternative is to request a more restricted choice based on professional judgment of need. While this may be adequate in many situations and avoids any redundancy or duplication, it leaves open the risk that the first round of investigation does not yield the expected results. A second round of diagnostic investigation can delay diagnosis and cause stress and frustration in patients, especially if the hospital is remote from their home. Also, in the modern litigious world in which we now operate, some medical professionals, especially junior members of staff who can be left to deal with initial diagnostic screening, may be wary of 'missing something' and consequently feel inclined to request the most rigorous set of diagnostic examinations. There is no universal answer to finding the correct balance, but someone should be responsible for proactive oversight and review to provide appropriate feedback. There are evidence based/expert opinion guidelines available in the UK, e.g. 'Making the best use of clinical radiology' published by the Royal College of Radiologists. These are available electronically in the work place and much greater and better use of them should be actively encouraged.

Professional radiographers, if properly empowered, can assist the radiation protection culture by influencing how radiography is seen by other healthcare professionals within the multi-skilled teams, e.g. by enhancing their role as the 'challenge' in the system for requesting and justifying exposures, and promoting awareness of the requirements of the Ionising Radiation (Medical Exposure) Regulations 2000 (IRMER) particularly amongst physicians.

In this digital age, there are good opportunities to enhance the sharing of previous diagnostic information or images thereby reducing the need to repeat radiation exposures for information that already exists. These opportunities are not always taken, and there remains scope for the better use of previous images and diagnostic data, or prior evaluations thereof. Repeating an exposure when the expected information is already available cannot be a justifiable request and is contrary to the current patient protection legislation.

The medical professional bodies could develop and promote further training for common application across the UK health service. There is a limited understanding within the UK of the requirements of the radiation legislation within the medical and the allied healthcare professions. This problem is highlighted in a recent survey of trainee radiologists, from 13 NHS hospitals, who had already worked in a radiation protection environment for an average of 1.6 months (Marsden 2014). The results of this questionnaire-based survey on basic radiation protection practices are shown in figure 2 and the high percentage of 'No' responses to the questions indicate that methods should be implemented for identifying areas of limited understanding or ignorance of good practice, and simple but effective guidance of the key requirements should be produced to assist awareness particularly amongst physicians. Anecdotal evidence (Marsden 2014) suggests that infection control far outstrips radiation protection in terms of safety culture amongst this staff group. This implies we could learn something from instilling safety culture from other risk areas.

Question	% 'No' Responses
Were you introduced to radiation protection at work?	23
Did anyone talk to you about your safety?	27
Did anyone talk to you about patient safety?	27
Do you know who your Radiation Protection Supervisor is?	68
Has anyone explained Controlled Areas to you?	86
Have you been shown how to use x-ray equipment?	45
Have you been told when to wear a lead apron?	36
Have you been given a copy of the Local Rules to read?	81
Have you been given a personal dosimeter?	36
Do you know where to wear it?	36
Do you know when to give your personal dosimeter back?	59

Figure 2. Results of a 2014 survey of trainee radiologists from sample of 13 UK NHS hospitals.

Radiologists and radiographers receive training in radiation protection, justification, optimisation, and methods of patient dose reduction. However, a comparable level of training is not necessarily received by other medical professionals who request procedures that use ionising radiations. Overall there seems to be the potential to improve technical training in certain areas of the medical profession.

In the UK healthcare sector, the level of radiation protection culture is generally low. In the authors' experience some hospitals only grudgingly have a 'compliance' culture. In other hospitals 'good practice' actions are driven by the fear of non-compliance rather than staff dose reduction. Regulator activity levels in UK hospitals have been low for many years. This is due to the low level of resources available to healthcare sector regulatory bodies for proactive inspection programmes. Nevertheless, in the UK healthcare sector, the low level of regulator activity must have in part contributed to the overall low levels of radiation protection culture in this sector. The implication is that radiation protection culture, at least in the healthcare sector, will not develop well and/or flourish without the key driver that is regulatory pressure. It is perceived by the authors that regulatory pressure has been, and continues to be, a strong driver within the nuclear industry sector, and that a change of mind-set is required within the medical sector for a good radiation protection culture to grow.

Nonetheless, a good radiation protection culture within the healthcare sector must include better education for users of radiation, enabling them to proactively ask questions such as:

- What happens to my/patient dose when I change the magnification factor or filtration in interventional radiology?
- How can I reduce my finger dose when drawing up an injection of a radiopharmaceutical?
- What do I need to do differently in the PET suite as opposed to a conventional gamma camera room?

In addition, radiation protection procedures must be written so that they mean something to the user. Good radiation protection practice must be rewarded and bad practice not tolerated. Healthcare staff must be encouraged to report incidents (without fear of blame) so that lessons can be learned. Tools must be provided and techniques adopted for auditing culture, but at the same time the process must be proportionate and enabling rather than preventative.

14. Specific factors: the nuclear industry

The public perception of the nuclear industry and the safety thereof is different to their feelings about the healthcare sector, and arguably the media's attention is more focused upon the nuclear industry and its apparent safety failings over the last 50 years, particularly post-Fukushima. This pressure has historically influenced the nuclear industry management's desire and efforts to address general safety culture and radiation protection culture more keenly than the healthcare sector.

There are significant financial and programme pressures on nuclear industry management and employees. Combined with the technical difficulty of some decommissioning operations, the demands within the nuclear industry are as great as those in the medicine sector.

Considerable effort has been put into safety culture improvement on several nuclear industry sites, and good safety performance is a significant strategic requirement. However, improving and even maintaining a strong culture is an on-going process. Any inappropriate change in priorities will discourage progress.

A significant difference in the radiological practices between a nuclear site and a hospital is that while there are a limited percentage of the workforce in a hospital who work with radiation, a large proportion of employees will do so on a nuclear site, and radiation safety is widely accepted as a core issue. Embedding cultural changes on a nuclear site is very challenging due to the number of people involved in working with radiation, the diversity of tasks that could potentially lead to radiation exposure of worker and, in some cases, its geographical size.

Perhaps the importance of individual worker responsibility to ensure the personal application and ownership of ALARP is more important than in the healthcare sector. For example, information about various area dose-rates may be more readily available and awareness of the variations in radiation level around a work area can make a significant difference to the dose received during the task. It appears that some nuclear industry workers have shown consistently lower doses than others for the same tasks, and their skills or awareness needs to be instilled in all colleagues.

15. The way forward

The SRP and the IRPA are committed to the task of assisting all relevant parties to develop and implement an effective radiation protection culture in the workplace. The UK views and experiences will also be made available to the on-going international programme, from which we expect useful input to our work.

It is proposed that radiation protection professions working in key areas in both the nuclear industry and the medical sector, and indeed in other sectors, should develop an action plan to achieve this. Examples of suitable action plans to assist in this process are shown in tables 1–3. SRP and IRPA have a keen interest in assisting this goal by developing 'culture improvement tools' and offering whatever help and support they can.

Such 'culture improvement tools' could include, e.g.

- Training lectures—on radiation protection awareness and cultural development which are specifically matched to different types and levels of staff
- Interactive training materials that are targeted at particular cohorts of staff for maximum effect
- Audit tools—may include software tracking dosimetry usage or template questionnaires for staff feedback on bad or good, and suggestions for better, radiation safety practices

Table 1. Example improvement plan for the medical sector.

Medical Safety Culture Improvement Actions	**Action placed on:**
Middle managers and/or radiation protection professionals to become champions of change within their organisation to seek support from all levels in the organisation for radiation safety culture improvement. This could be implemented and reviewed at the organisation's annual radiation safety committee (RSC) meeting. Individuals could be assigned specific areas to 'champion'. Champions could work alongside and support the 'shop-floor' RPS to proactively encourage training, audits, reviews, etc.	
RPAs and other RP professionals to engage with senior management to emphasise the benefits of a strong radiation protection culture and to seek ownership of the need for continuous improvement.	
RPAs and other RP professionals to seek support from senior management to engage with Employee Representatives to emphasise the benefits of a strong safety culture and to seek their support in direct involvement and participation in a programme of continuous improvement. The production of annual 'ALARP Reports' would be useful in achieving such an action.	
RPAs and other RP professionals to assess the current level of safety culture on your site throughout all levels of staff by encouraging senior management to use the INSAG-15 Questionnaires	
RPAs and other RP professionals to engage with senior management to encourage (further) development of the Learning Organisation and establishment or development of Operation Experience Feedback (OEF) procedures	
Senior management to develop a plan on how to engage stakeholders, i.e. all of the key people round the table when discussing treatment, e.g. consultants, nurses, patients, etc.	
Professional bodies to develop training/coaching on non-radiation non-technical skills (e.g. communication, management, budgeting etc) and focus on the benefits of developing radiation protection professional respect.	
Professional bodies to identify all existing and new technology that impacts on patient dose and improve training standards to determine who can be considered a 'trained operatives'.	
Develop simple messages around the radiation exposure control—concise/consistent/ correct, clear on benefits of properly justified and optimised exposures, and endorsed by professional bodies (e.g. SRP, RCR, SCoR and/or IPEM). Messages need to align with stakeholder responsibilities' and roles.	
Professional bodies/societies, together with the regulator (e.g. CQC) to develop, implement, and assist in training, for medical personnel requesting radiation services at the heart of medical training. This might feed into future revisions of the European and/ or national legislation. Target at a sensible point of training, i.e. when they become responsible for requesting services, e.g. 5th year of doctors training and not before. Clear on benefits of dose control for patient and staff, e.g. resource use and costs. Direct simple and memorable training.	
Examine how communication 'disconnects' can be tackled to prevent poor communication and dismantle barriers to developing inter-professional relationships, e.g. effects of electronic request systems.	
Look at possible barriers inside decision making processes and investigate ways to resolve conflicts due to different priorities, e.g. pressures to reduce waiting lists or increase throughput versus radiation safety.	

(Continued)

Table 1. (Continued)

Medical Safety Culture Improvement Actions	**Action placed on:**
Investigate methods to improve the RPS's and professional radiographer's ability to influence how radiography is seen by other medical professionals within the multi-skilled teams.	
Discuss with regulators how they can help the development and implementation of these actions.	
In collaboration with existing regulator-driven initiatives, professional bodies to develop guidance on how to (a) encourage a culture of reporting and learning, and (b) how to get feedback to the right place. In radiotherapy there is already a national 'learning culture' so this could be used as a model for other roles.	
In collaboration with its partner societies, the SRP to develop promotion material for advertising roles of radiation protection personnel in the healthcare sector. This could feed into universities and colleges offering degrees in diagnostic radiography, radiotherapy, etc.	

Table 2. Example improvement plan for the nuclear industry.

Nuclear industry Safety Culture Improvement Actions	**Action placed on:**
Middle managers and/or radiation protection professionals to become champions of change within their organisation to seek support from all levels in the organisation for safety culture improvement.	
RPAs and other RP professionals to engage with senior management to emphasise (or reiterate) the benefits of a strong safety culture and to seek ownership of the need for continuous improvement in this area. This could initially be progressed by RPA presentations to senior management and/or financial management meetings in addition to safety committee meetings.	
RPAs and other RP professionals to seek support from senior management to engage with employee representatives to emphasise the benefits of a strong safety culture and to seek their support in direct involvement and participation in a programme of continuous improvement.	
RPAs and other RP professionals to assess the current level of safety culture on your site throughout all levels of staff by encouraging senior management to use the INSAG-15 Questionnaires	
RPAs and other RP professionals to engage with senior management to encourage (further) development of the Learning Organisation and establishment or development of Operation Experience Feedback (OEF) procedures	
RPAs and other RP professionals to encourage the establishment of links with other sites to share knowledge and experience on Safety culture improvement	
RPAs and other RP professionals to consider what additional support and skills will enable us as individuals to deliver our roles most effectively and avoid the perception of erecting hurdles to effective project delivery where these exist. Possible examples include; Engaging with our professional societies to seek support and assistance to initiate safety culture improvement Benefits in improving soft skills such as persuasion and empathy and where these can be acquired Understanding what is involved in becoming a learning organisation and the specifics of OEF	

Table 3. Example improvement plan for professional societies.

General Safety Culture Improvement Actions	Action placed on:
Use existing work from IAEA, INPO, and WANO on safety culture to extract relevant aspects of use and/or relevance for radiation protection.	
Connect with other industry institutes who deal with radiation professionals to seek their contribution, e.g. The British Institute of Non-Destructive Testing.	
Establish the needs of the professional affiliations of small companies who use industrial radiography and seek to connect into those needs.	
Risk perception of exposures—consultation can cause further perception problems and erosion of status, i.e. perceived as a blocker not a legitimate risk reduction service.	
Risk balance—radiation not seen as 'high risk' until overexposure events occur then seen as a 'very high risk'. Organisations handling of risk balance crucial in the perception of non-radiation specialists' interaction.	
Engage with regulators to seek assistance, support and advice on implementing local initiatives and support radiation risk management and optimisation by radiation professionals.	
Consider expanding advice, training and support and/or strategies to assist: Non-technical Skills (e.g. communication, presentation and influencing/assertiveness skills) for radiation protection professionals who desire it. Key procedural systems, such as Operation Effectiveness Feedback (OEF) Front line management such as Radiation Protection Supervisors (RPS) to enable the sharing of experience and good practice and assist the implementation of ways to minimise dose without affecting operational delivery.	
Inside learning from mistakes—structure the learning from the professional body Radiotherapy/Radiology—issues around confidentiality and closed inside the organisation. Industry—collation and relevancy needed— 'this is what happened and why it happened' straightforward messages needed. Both also have potential barriers from litigation activity.	
Radiation information is difficult to get over to non-radiation professionals—concepts are difficult—SRP/IRPA could assist with back up advice and support material for the professional to get over the key messages to, e.g., finance managers.	
The ALARP/Optimisation message is difficult to get over to non-radiation professionals and it can mean different things to different people in the decision making chain. Support material would assist in cost/benefit discussions.	
Discussion is needed on the effects of privatisation and personal accountability. This can create both positive and negative influences on motivation, blame culture, litigation, and personal control.	

- Methods and software tools for measuring improvements is radiation protection culture pre/post implementation of changes.
- Guidance notes on implementing incentives for staff at all levels to take ownership of various aspects of radiation protection
- Proposal for culture 'champions' within an organisation.
- A clear financial and operational case for the benefits to any establishment (nuclear or medical) of radiation protection, improving the culture thereof, and the corporate, health, fiscal, reputational etc hazards of getting it wrong.

- A proposal to establish, and an invitation to join, a UK radiation protection culture network
- A list of contacts for help in improving radiation protection culture
- Links to web-based resources on radiation protection culture improvement methods that will have been set up by SRP, IRPA, and partner societies.

SRP and its Partner Societies have decided to extend the life of the Working Group and have established several sub-groups to take forward the work in the different sectors. An open Workshop/meeting will be held in 2015 to review progress and an update on the UK approach to RP Culture development will be prepared for the IRPA14 International Congress in Cape Town in 2016.

Appendix. UK partner societies

The Society for Radiological Protection (SRP)
The Association of University Radiation Protection Officers (AURPO)
The Institute of Physics and Engineering in Medicine (IPEM)
The Royal College of Radiologists (RCR)
The British Institute of Radiology (BIR)
The Society and College of Radiographers (SCoR)
The British Nuclear Medicine Society (BNMS)

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