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EDITORIAL

Optimisation in daily practice – it's more than just radiation dose

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In radiology and radiation therapy, optimisation is generally thought of in terms of physics – dose needs to be optimised (ALARA or As Low As Reasonably Achievable), image quality (e.g. signal to noise ratio (SNR)) needs to be optimised, computer workstation displays need to be optimised (e.g. calibrated to the DICOM GSDF – Digital Imaging and Communications in Medicine Grayscale Standard Display Function) and so on. This type of optimisation, although often challenging to achieve, is fairly easy to think of, study and implement as these variables are based for the most part on measurable physical properties of different technologies throughout the imaging chain. A number of articles in this special issue deal with this type of optimisation,[1–3] illustrating that no matter how well we think we have tackled some of these basic issues, there is still much work to be done and the innovative approaches proposed get us one step closer to optimisation.

A bit more complex to quantify and optimise are imaging aspects readily impacted by less controllable and quantifiable variables such as imaging skill, training and experience with respect to image acquisition;[4] patient and anatomic variability that affect image quality and models for optimising treatment planning;[5] judgement calls about when and how to image and conduct procedures;[6] and increasingly the economics[7] of health care as other papers in this special issue emphasise.

These types of factors raise the question of whether certain imaging aspects can really ever be optimised. Optimisation implies that once it has been achieved a given process cannot be further improved upon, yet with the amount of inherent variability in not only patients but radiographers, radiation therapists and educators, it is sometimes difficult to believe that every aspect of the image chain could ever be optimised. The type of research presented on these topics in this special issue, however, indicate that these issues are clearly addressable and at the very least can be improved upon through better understanding of processes and procedures.

Why is the optimisation of diagnostic imaging and radiation therapy in terms of diagnostic and therapeutic tests and treatments, education and service provision so important? The obvious answer is to provide the most effective care in the most efficient manner so that outcomes and quality of life for patients in our care are as consistent, reliable and of the highest quality possible using the best techniques and technologies available. From a slightly different perspective, radiographers, radiation therapists and educators should be looking at optimisation in daily practice for their own benefit and well-being. Even with the potential benefits being touted by the increasing use of deep learning and artificial intelligence for nearly every facet of medical radiations professions, image acquisition and interpretation is still very much in the hands of human operators.[8] As such, we need to consider these human health professionals as integral links in the imaging chain and seek ways to optimise *their* physical, mental and emotional well-being. If we do not, errors occur and patient care is potentially impacted negatively, as are the health professionals themselves (e.g. reprimands, injuries, burnout).

To date, there is more research than in the past being conducted on human factors, fatigue and burnout in radiologists, but the causes, results and implications are the same for all those working in radiology and radiation therapy services. For over 10 years, a number of us have been studying the impact of fatigue on radiologists' performance interpreting a variety of imaging studies (e.g. nodule detection in chest x-ray and CT images, fractures in bone image, multiple trauma in CT).[9,10] It has been consistently shown that after an average of just 8 hours of imaging work (when most workdays last much longer than that), radiologists are significantly less able to visually accommodate (i.e. focus) especially at near distances (i.e. on diagnostic displays), have significantly reduced diagnostic accuracy (on average about 4% with increases in *both* false positives and negatives), become less efficient in their search strategies as evidenced by eye-tracking measures, and possibly reduce the quality of their reports as evidenced by inclusion of less information.

Of interest, and what has been rather surprising, is that overall residents are actually more negatively impacted by fatigue than consultants. When we started out, we hypothesised that the residents would be less impacted given that they are younger and generally have better visual health (or at least younger eyes). What became apparent, however, is that simply being a trainee is physically and mentally taxing – they are constantly learning, worrying about making errors, and taking on more responsibility as they read more independently – all while also figuring out how to maintain equilibrium in their lives in and outside of work.

More experienced radiologists obviously have more responsibilities, are being pressured to read more images in less time, teach and so on, but it seems they have generally developed mechanisms to deal with these pressures and manage their fatigue somewhat better. These results are likely generalisable to trainee radiographers and radiation therapists; thus, educators must be aware of the potential 'failure points' as fatigue sets in and help trainees develop the skills to recognise the warning signs and adopt coping mechanisms. No matter how well the technology the user interacts with is optimised, if fatigued errors can and will occur.

Fatigue is only one factor contributing to less than optimal performance and in the longer-term burnout among those employed in radiology and radiation therapy practices. There is growing recognition that human factors and ergonomics must be considered when designing new technologies, creating working spaces and optimising workflow processes and procedures. Work activities and tasks differ for radiologists, radiographers and radiation therapists, but all are physically demanding in different ways, and injuries often occur. Careful observation and study of work environments and activities can help identify sources of potential pain and injury so interventions and adjustments can be made to improve them. For example, radiologists in the digital environment sit for far more hours than they used to, with resulting musculoskeletal symptoms that do interfere with their work.[11] Designing better chairs, work surfaces (e.g., height-adjustable monitor stands and desks) and tools (e.g. mice, dictation systems), as well as teaching them good ergonomic habits (e.g. use the 20-20-20 rule or every 20 minutes look 20 feet in the distance for 20 seconds) can reduce the likelihood of potentially chronic physical injuries.

Radiographers in particular are exposed to situations where physical injuries (acute and chronic) often occur. They must directly interact with patients of all sizes, shapes, mobilities and levels of cooperation, but also need to deal with technologies that often are not optimised for anyone other than the average user. Sonographers in particular are known to experience hand and wrist injuries due to the non-optimal design of many transducers and the techniques and manipulations required to obtain images of adequate quality not what the patient size, position or ability to move.[12] Training and education on the 'proper' techniques to use only help so far, since what works for one person may not always work for someone else. The problem with most working environments, including radiology and radiation therapy, is that work environments and equipment are 'optimised' using a one-size-fits-all approach making it difficult to optimise things for the individual operator.

Optimisation of the technologies, processes, workflows and the overall environment within which radiographers, radiation therapists and educators operate on a daily basis can help ameliorate the potentially negative impacts of the increasingly complex and stressful healthcare enterprise within which we work. We must approach optimisation from a much broader perspective however than is traditionally considered. We must take into account the user as an integral component of an intricate, complex and everchanging ecosystem and optimise the various components of this ecosystem in a synergistic fashion rather than piece-by-piece in isolation. Each of the papers in this special edition illustrates an important segment of the complex nature of the practice of radiology and radiation therapy, providing valuable information for optimisation, yet also raising even more questions and room for future research.

Conflict of Interest

The author declares no conflict of interest.

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