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Volume 34 | Issue 03 | Autumn 2024

IPEM
Institute of Physics and Engineering in Medicine

SCOPE

CANCER TRACERS UNDER THE MICROSCOPE

Will FAPI replace FDG?

IPEM MANIFESTO

IPEM sets out the key sector challenges for the new government

DOSE MANAGEMENT

A medical imaging software survey and discussion of the results

REAL-WORLD EVALUATION

Repetitive transcranial magnetic stimulation for psychiatric illnesses

QUALITY CONTROL

Linac risk management to improve safety and efficiency

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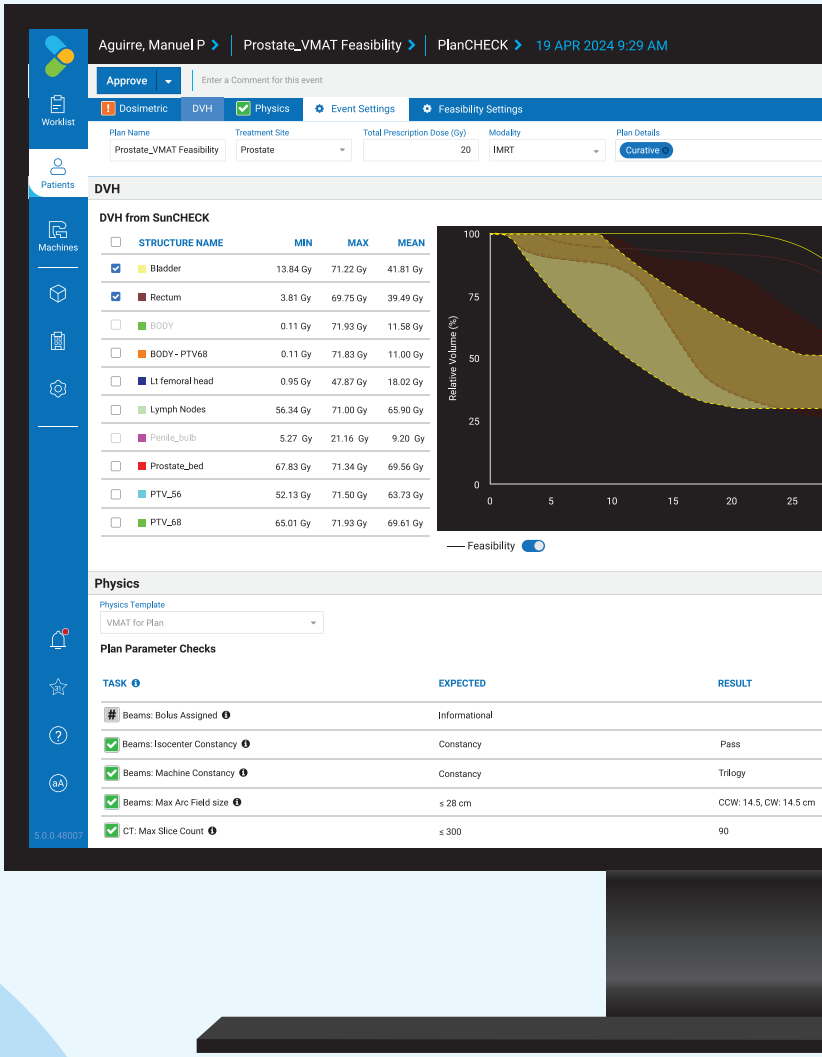

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Strike a balance of content

Usman Lula outlines the content in the latest issue, including cancer tracers, AI and dose management software.

Welcome to the Autumn 2024 issue of *Scope* magazine. This summer was an 18-day road trip across England, Scotland and the Isles. I drove over 2000 miles, from the Lizard Peninsula's rugged cliffs to the Scottish Highlands and the windswept Isles of Lewis and Harris. Along the way, with my family, we explored the National Marine Museum, the Eden Project and the National Museum of Scotland, soaking in the UK's breathtaking scenery and rich history. Grab a warm drink and dive into this autumn's exciting features.

In this issue, we've curated an interesting selection of features for all *Scope* readers. Our goal is always to strike a balance in our content, covering as many areas within medical physics, clinical engineering and biomedical engineering as possible. We uncover insights on cutting-edge cancer tracers in nuclear medicine, learn about innovative dose management software and look at AI's growing role in healthcare. We also cover advances in non-invasive neuromodulation, precision quality control of linear accelerators and the dynamic field of health data science. Prepare to dive in and enjoy!

In our regular "Member Profile" segment, we feature Dr Benjamin Metcalfe, an academic specialising in biomedical engineering and human augmentation. He shares insights into his typical day, the aspects of his job he enjoys most, changes he would make in his field, his proudest accomplishments and his involvement with IPEM. This profile offers a fascinating look into what it takes to be a leader in the field and the strategies for achieving success.

> Throughout our discussions, your readership remains our compass, guiding every decision we make

We are currently seeking article submissions covering clinical practice developments, leadership and management, teaching, training or topical issues to ensure *Scope* remains current, relevant and balanced. Articles are welcome from all levels, including trainees, junior, middle, senior and retired staff.

Our dedicated *Scope* Editorial Advisory Board convenes quarterly to curate a diverse array of content tailored to your interests. Throughout our discussions, your readership remains our compass, guiding every decision we make. We value your input and invite you to share your ideas, feedback and potential contributions, as your input is invaluable to our collective efforts. Don't forget – your submission counts towards your CPD. If you need an incentive, your feature could be chosen for the annual Keith Boddy award – that's £250 in your pocket plus a certificate. If you would like to contribute to *Scope*, please get in touch with me, our Editor or any of our *Scope* Editorial Advisory Board members.

Enjoy the read.

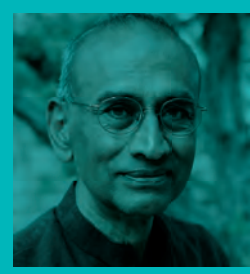
Usman Lula

Usman Lula
Chair of IPEM Scope EAB

BOOK PITCH

Why do we die? Insights on a profound issue

We aim to ensure your magazine is filled with interesting, engaging and valuable material, whilst we continue to improve the quality of the content. In a unique addition to this issue, we feature a "Book Pitch" on the science of ageing and the pursuit of immortality. Some of you might wonder why this topic is included in *Scope*. I believe that, at its core, the work in our fields is ultimately about improving and saving lives. Our goal also includes extending life itself, which requires understanding the fundamental question: why do we die? Nobel Prize-winning biologist Venki Ramakrishnan offers insights that help us explore this profound question.



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CO

COVER FEATURE

> FAPI has been shown to have superior sensitivity but poorer specificity in a couple of metanalyses, often due to tumour induced pancreatitis and cholangitis increasing uptake that masks the tumour.
>
> ***Jan Walukiewicz,***
> *Senior Clinical Scientist* page 22

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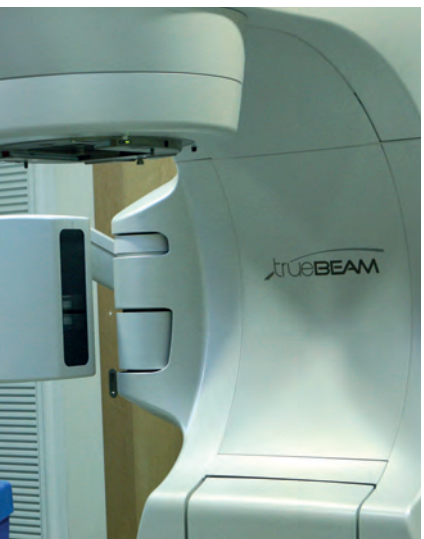
GENERAL



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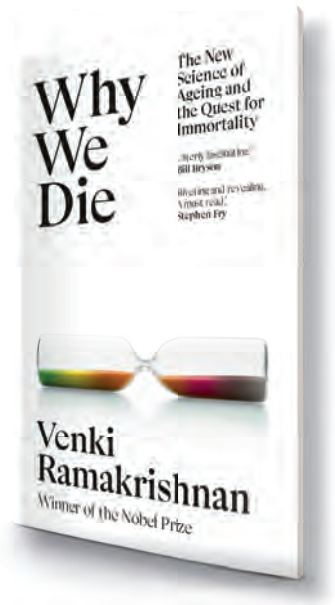

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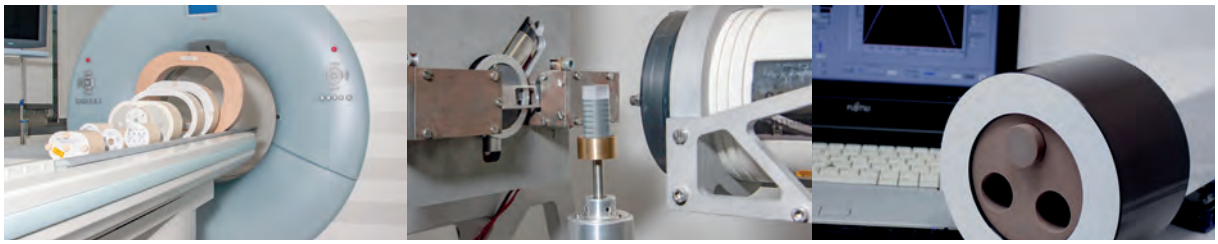
QRM Phantoms



A comprehensive range of phantoms for all situations

Phantoms are specially designed objects that are scanned or imaged to analyse the accuracy and efficiency of a wide range of processes in medical imaging. PTW have teamed-up with QRM to provide a huge range of phantoms for all your needs. Here are a few examples:

The Spectral CT Phantom

The Spectral CT Phantom is used to test different types of CT modalities with dual-energy, multi-energy or photon-counting setups and is available in 4 (QRM-10139) and 8 (QRM-10147) hole versions. The 20 mm inserts are available in a wide range of tissue types and Iodine/ CaHA concentrations

The Comprehensive Electron Density Phantom

The Comprehensive Electron Density Phantom (QRM-90114) is used to calibrate the HU/electron density conversion for CT datasets used for radiotherapy treatment planning. 16 rods mimic a variety of tissue densities and conform to ICRU recommendations. Suitable for photon, electron and proton planning processes

The Cone-Beam Phantom

The Cone-Beam Phantom, Expert (QRM-10103), for testing the imaging performance in diagnostic and cone-beam CT, has low contrast sections providing contrasts between 3 and 200 HUs. Spatial resolution line patterns from 4 to 30 lp/cm and an additional edge insert determine the system MTF in different orientations.

In addition to our standard range, we can design bespoke phantoms for medical, industrial and research purposes. For more information on our range of QRM phantoms and to see what PTW can do for you visit https://www.qrm.de/en/, or contact us at PTW-UK: sales2.uk@ptwdosimetry.com

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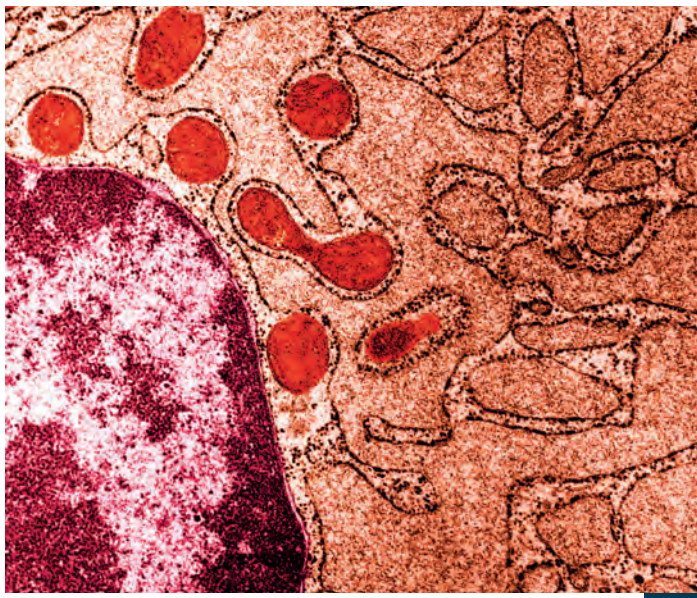
UPFRONT



PLASMA PROTEINS

Blood proteins predict the risk of more than 60 diseases

Research on thousands of proteins measured from a drop of blood demonstrates the possibility of using proteins to predict the onset of many diverse diseases.

The work was carried out as part of an international research partnership between GSK, Queen Mary University of London, University College London, Cambridge University and the Berlin Institute of Health at Charité Universitätsmedizin, Germany.

The researchers used data from the UK Biobank Pharma Proteomics Project – the largest proteomics study to date, with measurements for approximately 3000 plasma proteins from a randomly selected set of over 40,000 UK Biobank participants.

The protein data is linked to the participants' electronic health records and the authors used advanced analytical techniques to pinpoint, for each disease, a "signature" of between the five and 20 proteins most important for prediction.

The researchers report the ability of protein "signatures" to predict the onset of 67 diseases including multiple myeloma, non-Hodgkin lymphoma, motor neurone disease, pulmonary fibrosis, and dilated cardiomyopathy.

The protein prediction models out-performed models based on standard, clinically recorded information. Prediction based on blood cell counts, cholesterol, kidney function and diabetes tests performed less well than the protein prediction models for most examples.

This research opens up new prediction possibilities for a wide range of diseases, including rare conditions, many of which currently take months or years to diagnose.

These findings require validation in different populations, including people with and without symptoms and signs of diseases and in different ethnic groups.

Professor Claudia Langenberg, Director of the Precision Healthcare University Research Institute (PHURI) at Queen Mary University of London and Professor of Computational Medicine at the Berlin Institute of Health at Charité Universitätsmedizin, said: "Measuring one protein for a specific reason, such as troponin to diagnose a heart attack, is standard clinical practice. We are extremely excited about the opportunity to identify new markers for screening and diagnosis from the thousands of proteins circulating and now measurable in human blood. What we urgently need are proteomic studies of different populations to validate our findings, and effective tests that can measure disease relevant proteins according to clinical standards with affordable methods."

First author Dr Julia Carrasco Zanini Sanchez, research student at GSK and the University of Cambridge at the time and now postdoctoral researcher at PHURI, added: "Several of our protein signatures performed similar or even better than proteins already trialled for their potential as screening tests, such a prostate specific antigen for prostate cancer."

b.link/q4yyroz4

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FAST FACTS

67
DISEASES
The researchers report the ability of protein "signatures" to predict the onset of 67 diseases.

5–20
PROTEINS
Signatures of between the 5 and 20 proteins were created.

40,000
PARTICIPANTS
The researchers used plasma proteins from over 40,000 UK Biobank participants.

DIAGNOSTIC EFFICIENCY

Cloud-magnetic resonance imaging system

A new cloud-magnetic resonance imaging (MRI) platform has been developed in China that it is claimed facilitates seamless data sharing and improves diagnostic capabilities across healthcare institutions.

"Traditional methods of managing MRI data face significant limitations, from storage constraints to barriers in collaborative research," said Professor Xiaobo Qu of Xiamen University. "Our system will address these challenges by harnessing the power of distributed cloud computing, ultra-fast 6G bandwidth, edge computing, federated learning and blockchain technology."

The core of the cloud-MRI system is its capability to upload k-space raw data, essential for MRI reconstruction, to unified servers or local edge nodes in the ISMRMRD format – a standard vendor-neutral file format for MRI research and development. This facilitates rapid image reconstruction and enables AI tasks, significantly enhancing diagnostic efficiency.

It is claimed to enable multiple vendor data reading, AI-based MRI image reconstruction, radiologists' blind image quality evaluation, metabolic spectrum analysis and AI programming without coding.

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DRUG DELIVERY

"SMALLEST EVER FREE-FLOATING STRUCTURES FOR MEDICAL IMAGING"

Bioengineers have developed ultrasmall, stable gas-filled protein nanostructures that could revolutionise ultrasound imaging/drug delivery, they claim.

IMAGE: ANNA STAFFORD/RICE UNIVERSITY

At present, microbubbles or nanobubbles are too large to cross biological barriers effectively.

However, the novel diamond-shaped 50-nanometer gas vesicles (50-NM GVs) – approximately the size of viruses – are believed to be the smallest stable, free-floating structures for medical imaging ever created.

Microbubbles have enabled promising recent advances in ultrasound imaging and drug delivery. Used as contrast agents, they can deliver molecular-level information on targeted biomarkers or cell types. However, due to their large size (1-10 micrometers in diameter), they can rarely leave the bloodstream, restricting their effectiveness to well-vascularised tissues.

The new 50-NM GVs can penetrate tissue with the research showing they were able to reach important immune cell populations in lymph nodes.

The teams said this opens up new possibilities for imaging and delivering therapies to inaccessible cells.

b.link/mix15zsp

NEWS IN BRIEF

Meningioma tumours

Drugs developed to fight blood and other cancers could help improve the efficiency of radiotherapy in meningioma brain tumour in adults, a new study has found. Meningioma is usually treated by surgery, but some which can't easily be accessed need to be treated with radiotherapy. Researchers at the University of Plymouth discovered by administering the HDAC6 inhibitor Cay10603 prior to radiotherapy, they were able to inhibit cellular growth – and increase cell death – in meningioma samples.

b.link/rfprwx5y

Parkinson's subtypes

US researchers have used machine learning to define three subtypes of Parkinson's disease based on the pace at which the disease progresses. In addition to having the potential to become an important diagnostic and prognostic tool, these subtypes are marked by distinct driver genes. If validated, these markers could also suggest ways the subtypes can be targeted with new and existing drugs. They were able to identify the subtypes by using deep learning-based approaches to analyse deidentified clinical records from two large databases.

b.link/4ukhzo38

Soft rehab gloves

Soft rehabilitation gloves can help patients with hand function-related disabilities recover finger movement. They often use soft pneumatic actuators that employ air pressure to generate movements. Many available soft actuators have drawbacks in achieving bidirectional motion typical of finger joints. Biomedical researchers from Chiba University have overcame this design limitation by developing a novel foldable pouch actuator that integrated with existing soft actuators in the rehabilitation gloves.

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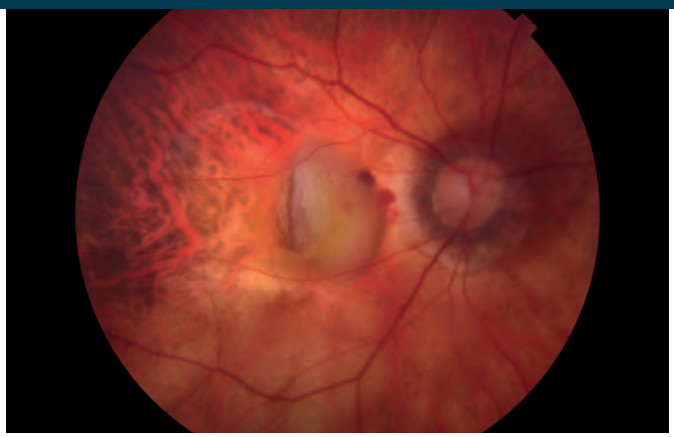

AGE-RELATED MACULAR DEGENERATION

Robot radiotherapy for eye disease

Researchers from King's, with doctors at King's College Hospital NHS Foundation Trust, have used a new robot system to improve treatment for debilitating eye disease.

The custom-built robot was used to treat wet neovascular age-related macular degeneration (AMD), administering a one-off, minimally invasive dose of radiation, followed by patients' routine treatment with injections into their eye.

In the landmark trial it was found that patients then needed fewer injections to effectively control the disease, potentially saving around 1.8 million injections per year around the world.

Wet AMD is a debilitating eye disease, where abnormal new blood vessels grow into the macula, the light sensing-layer of cells inside the back of the eyeball. The vessels then start to leak blood and fluid, typically causing a rapid, permanent loss of sight.

The new treatment can be better targeted than existing methods, aiming three beams of highly focused radiation into the eye. Scientists found that patients having robotic radiotherapy required fewer injections compared to standard treatment. The study found the device could save the NHS £565 per patient treated over first two years.

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CARDIAC FUNCTION

"AI MODEL GIVES MRI RESULTS IN SECONDS"

A method for analysing heart MRI scans with the help of AI has been developed, which it is claimed could save NHS time and resources and improve patient care.

Teams from across the UK created an intelligent computer model that utilises AI to examine heart images from MRI scans in a specific view known as the four-chamber plane.

The 4D MRI imaging technology could pave the way for faster, non-invasive and more accurate diagnosis of heart failure and other cardiac conditions.

Lead researcher Dr Pankaj Garg, said: "The AI model precisely determined the size and function of the heart's chambers and demonstrated outcomes comparable to those acquired by doctors manually but much quicker."

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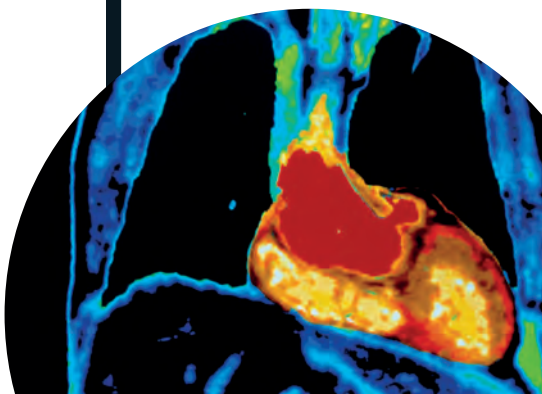

UP CLOSE

PRECISION MEDICINE

WHAT IS PRECISION MEDICINE?

It aims to tailor treatments to individual patients to get the best possible outcomes. This is does this by considering factors specific to the patient, such as the patient's genetics, environment, lifestyle and more.

WHAT IS THE LATEST NEWS?

Top experts from around the world have developed the first comprehensive guidelines for reporting precision medicine research in a bid to improve patient care and health equity for people everywhere.

WHO IS BEHIND THE GUIDELINES?

The BePRECISE consortium, which includes 23 global experts in precision medicine, cardiometabolic diseases, statistics, editorial and lived experience. The group created the new guidelines after conducting a review of the existing precision medicine research and identifying ways to improve how that research is reported.

WHAT DO THE RECOMMENDATIONS INCLUDE?

There is a checklist of practical recommendations that researchers can implement immediately. For example, the BePRECISE consortium members found that only 17% of the papers they reviewed included "precision medicine" in the paper's title or in the abstract summarising the work. That simple addition could make it much easier for doctors and researchers to find relevant information on the latest precision medicine findings.

WHERE CAN I READ THE GUIDELINES?

Visit the website **be-precise.org**

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IPEM REPRESENTATION

ESTRO 2024 CONFERENCE

Glasgow played host to the ESTRO 2024 Conference and Exhibition over the Bank Holiday weekend in May and IPEM was there to represent members' interests.

The theme of this year's congress was "Radiation Oncology: Bridging the Care Gap", which was a comprehensive look at where radiotherapy is today and where it is going, as well as focussing on where gaps in the provision of optimal radiotherapy can be bridged.

IPEM had a stand in the National Societies pavilion and Sally Hawking, Head of Commercial Engagement and Catherine Toon, Events and Conferences Manager, were supported on the stand by Patrick Downes, a member of the Radiotherapy Special Interest Group, with Dr Jemimah Eve, IPEM's Director of Policy and Impact, representing IPEM on the Radiotherapy Board stand.

For reports from the event, see pages 48–49.

REPORTS

Radiotherapy delays

Radiotherapy services are increasingly reporting long delays for patients needing treatment, according to a new report.

The Radiotherapy Board has developed a policy briefing, exploring the main drivers of lengthening waiting times and the action needed to support services.

IPEM is a member of the board, along with the Royal College of Radiologists and the Society and College of Radiographers.

Recovering radiotherapy services in England sets out a plan for action to address the long delays patients face for treatment.

The briefing explores the main drivers of lengthening waiting times and what action needs to be taken at a national and local level to support services.

It sets out 11 recommendations for how government and NHS England can restore radiotherapy services and ensure patients receive treatment in a safe and timely manner.

The board has also published the ESTRO-HERO report, which estimates the cost of radiotherapy to the NHS for the first time.

The model estimates the total cost of the 127,275 radiotherapy courses delivered in 2017 was £467m and points out that radiotherapy accounts for approximately 7% of the total cancer spend.

Dr Anna Barnes, IPEM's President, said: "These two reports once again highlight the delays patients face for cancer treatment. I hope the recommendations in the report are acted upon to restore radiotherapy services and ensure patients receive the treatment they need."

b.link/1px9w3ri

AWARDS

WINNERS ANNOUNCED

The winners of the Advancing Healthcare Awards have been announced.

IPEM sponsored the award for the "Best collaboration across clinical, academia and industry", which was won by Paul Lee, an IPEM member and Consultant Clinical Scientist, and Jordan Lee, an undergraduate Admin Assistant and Managing Editor of the *MDET* Journal, for "The safe use, storage and setup of medical gas cylinders used in healthcare".

The Academy for Healthcare Science award for Innovative Practice to Enhance Patient Safety was won by the Clinical Engineering Research and Development team from the Northern Care Alliance. The Christie medical physics and engineering MR physics group at the Christie NHS Foundation Trust were Highly Commended in the NHS England's Chief Scientific Officer's Award for the Outstanding Healthcare Science Service of the Year category.

IMAGES: ISTOCK/SCIENCE PHOTO LIBRARY

IPEM JOURNALS

INTERNATIONAL JOURNAL PRIZE WINNERS

The winning papers published in IPEM's international journals have been announced. They are: "Evaluation of cardiovascular and cerebrovascular control mechanisms in postural orthostatic tachycardia syndrome via conditional transfer entropy: the impact of the respiratory signal type", "Investigating the potential contribution of inter-track interactions within ultra-high dose-rate proton therapy" and "Prony Analysis of Left Ventricle Pressure and Volume".

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GUIDANCE

Medical radiation risks

Updated guidance on medical radiation risks and safety advice has been published with the help of IPEM members. The UK Health Security Agency has published the collection *Medical radiation: uses, dose measurements and safety advice*.

IPEM members Aida Hallam and Claire Skinner were IPEM representatives on the initial multidisciplinary working party set up by the Clinical Imaging Board to address the need for a national reporting and learning system to analyse and learn from incidents in diagnostic imaging, MRI and nuclear medicine in the UK.

Their findings proposed an error coding taxonomy and user guidance to support the UK clinical imaging community to develop local systems for reporting and analysing diagnostic and nuclear medicine ionising radiation incidents.

Dr Anna Barnes, IPEM's President, said: "It is so important for both patient and staff safety to keep guidance on radiation risks up to date and it is vital the clinical community are made aware of such advice."

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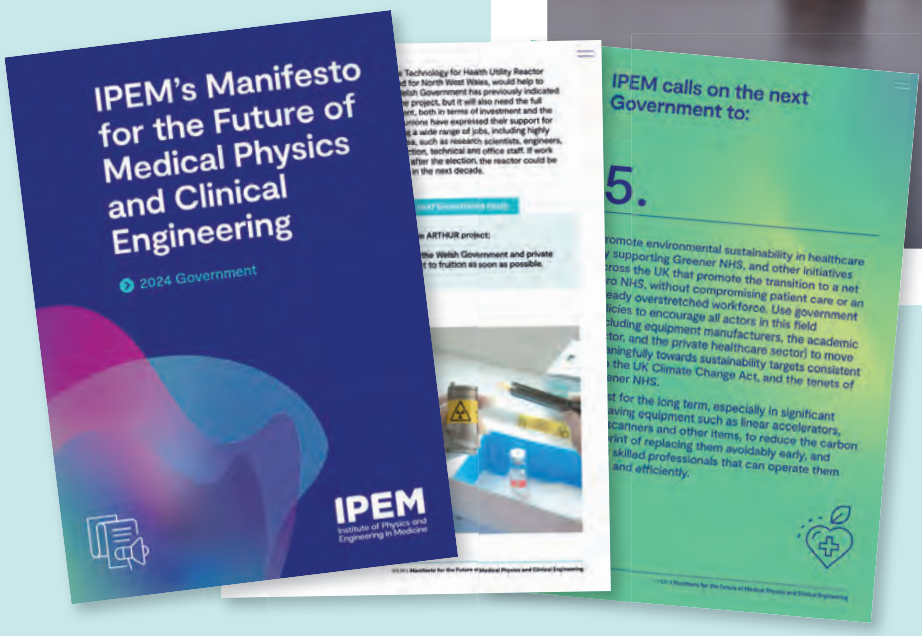
IPEM'S MANIFESTO

The future of the sector

Chris Watt, IPEM's Head of Communications and Public Affairs, outlines the content in a vital IPEM document that has been sent out to MPs.

IPEM's *Science Leadership Strategy* raises awareness of the key challenges that lie ahead for physics and engineering in medicine and biology and outlines how IPEM is a trusted and effective voice for the profession.

Ahead of this year's General Election, a number of our members collaborated to produce a manifesto for the future of medical physics and clinical engineering (MPCE). This clearly sets out some of the key issues facing us and how the new government can address them.



The workforce

Addressing the workforce crisis is probably the highest profile challenge facing the profession. Recommended staffing models show the MPCE workforce actually requires at least 900 additional staff to come from additional training opportunities, which will not be met by the commitments in the *NHS Long Term Workforce Plan.*

IPEM's official workforce statement, published in 2023, showed that, across all MPCE specialisms surveyed in recent years, there is an average 10% vacancy rate, ranging from 6% to 22% across the specialisms.

The professions IPEM represents are facing significant recruitment and retention issues, with an ageing workforce. In some MPCE professions, the number of staff due to retire within the next 15 years is over 30%. At the same time, of the specialisms that do have a regular intake of trainees, IPEM data has shown the number of trainees entering the workforce is not sufficient to maintain it.

IPEM is calling on the new government to invest in the MPCE workforce and use all opportunities to recruit more professionals, including apprenticeships and supporting necessary overseas recruitment. It also needs to address the lack of physics teachers in schools.

We also believe that clinical engineers and other registered professionals in medical physics should be included in the senior management decision making processes of every NHS trust, especially in the regulation of medical devices.

Clinical technologists

Clinical technologists are highly skilled, highly trained professionals who work in a wide range of essential services, including nuclear medicine, radiotherapy, bioengineering, dialysis and magnetic resonance imaging (MRI) and computed tomography (CT) scanning, among others. They work with hazardous substances and highly complex, potentially dangerous items of equipment and are entrusted and relied upon to keep their patients, colleagues and the public safe. Yet despite their patient facing roles, clinical technologists are currently subject only to voluntary registration.

IPEM has long believed that moving the registration of clinical technologists onto a statutory footing would provide greater public reassurance, giving the NHS more flexibility in the use of its workforce and improving patient care. IPEM is happy to work with the government and other partners to bring this about.

IMAGES: ISTOCK/GETTY

IPEM IS CALLING ON THE NEW GOVERNMENT TO INVEST IN THE MPCE WORKFORCE

Sourcing radioisotopes

Diagnostic procedures using radioisotopes are now routine, identifying cancers and illnesses such as heart disease earlier to improve outcomes and save lives.

Despite their importance, the UK now depends heavily on imports for key radioisotopes, many of which are supplied by air from South Africa and Europe. Issues with sourcing radioisotopes from overseas, such as technical problems with ageing reactors or geopolitical factors, can delay or even prevent the diagnosis and treatment of cancers, creating additional pressure on cancer waiting lists.

The lack of availability of radioisotopes is arising because many of the reactors that produce this material globally will be decommissioned within the next decade, many of them by 2030. For the benefit of patients in the UK, it is therefore vital that we have the ability to generate medical radionuclides in this country, which will also strengthen the global supply chain.

The Advanced Radioisotope Technology for Health Utility Reactor (ARTHUR), which is proposed for North West Wales, would help to address these issues. The Welsh government has previously indicated that it is willing to invest in the project and IPEM has recently written to relevant ministers to reinforce this position. However, it will also need the full support of the UK government, both in terms of investment and the regulatory landscape.

Artificial intelligence

Embracing the opportunities and facing the challenges of AI and emerging technologies, and creating a more sustainable healthcare system, were both identified as key issues in IPEM's *Science Leadership Strategy*.

AI has the potential to be an enabler of workflow productivity and innovative technologies, but is a step into the regulatory unknown. Digital technologies have the potential to improve rate and efficiency of research and development, reduce costs and reduce workload, particularly through easing administrative burden and accelerating analysis.

We must ensure the healthcare science community – at all career stages – has the skills to keep up with digital, technological and scientific change.

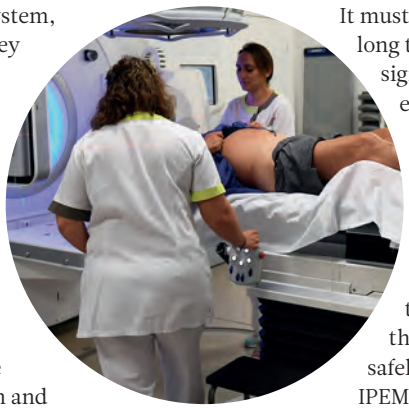
The new government must invest in training the current and future generation of healthcare scientists in next generation digital skills to enable them to embrace the opportunities of AI and other emerging technologies.

It also needs to review the current legislative and regulatory framework and bring in effective regulation for the governance of AI going forward and facilitate discussions, with a seat for the science community across healthcare, academia and industry, on how we ensure the safe, ethical and effective design and delivery of AI.

Sustainability

The professionals IPEM represents are committed to promoting environmental sustainability in healthcare by supporting Greener NHS, and other initiatives across the UK that promote the transition to a net zero NHS, without compromising patient care or an already overstretched workforce.

The government must employ policies to encourage all actors in this field (including equipment manufacturers, the academic sector and the private healthcare sector) to move meaningfully towards sustainability targets consistent with the UK Climate Change Act, and the tenets of Greener NHS.



It must also invest for the long term, especially in significant life-saving equipment such as linear accelerators, MRI scanners and other items, to reduce the carbon footprint of replacing them avoidably early, and in the skilled professionals that can operate them safely and efficiently.

IPEM has written to all relevant new Ministers with IPEM's manifesto, as well as MPs with an interest in our area of work. To read the manifest, visit **b.link/f4w0idm1**.

LEADING THE WAY

IPEM President-Elect **Mark Knight** talks about his plans for his tenure, from tackling workforce challenges to embracing new technology.

The weekly IPEM meetings chaired by IPEM President-Elect Mark Knight in early 2020 to deliver the national medical physics' response to the COVID-19 pandemic "really changed the game" for him. "How often can you get 50 radiation protection professionals, experts in their field, from across the UK, to work together on building that response?

"The questions that came up were really challenging and needed fixing very quickly. And people got together and did it," he says.

Mark has big plans for his tenure as President of IPEM, which will run from October 2025 for two years. In particular, the "huge challenge" of the medical physics and clinical engineering workforce crisis will be on the agenda.

"We should be looking at the accessibility of our programmes – have we got wide enough participation? Do we offer enough to people doing T Levels or apprenticeships, as well as the traditional routes? Is the consultant scientist programme accessible to people who have caring responsibilities or have been on a career break?"

People

Workforce shortages have been an issue as long as Mark has been working in the sector. Following a physics BSc at the University of Manchester, Mark completed the grade A and higher IPEM training schemes, which included a medical radiation physics MSc at Brunel University London.

He worked in diagnostic radiology, radiation safety and nuclear medicine in various NHS trusts before spending three and a half years in Qatar as Principal Physicist and Radiation Protection Officer at the Hamad Medical Corporation, setting up the country's first radiotherapy services. "We put the first digital imaging facilities in Qatar's national health service as well," he adds.

The next 16 years were spent in the operational role of Head of Radiation Physics at Maidstone and Tunbridge Wells NHS Trust. Since April 2023, he's held the strategic role of Chief Healthcare Scientist and Clinical Lead for Sustainability for NHS

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Kent and Medway Integrated Care Board.

His responsibilities cover pathology, physiological sciences, bioinformatics, and genomics, as well as medical physics and clinical engineering. "We're thinking about how scientists really integrate into medical programmes, and how are we making sure our scientists are right at the forefront of delivering some of those new technologies that will become available in medicine," he says.

Technology

New technologies pose another key challenge – and opportunity – for the sector, that can help with training and education. "We can use devices such as AI and virtual reality to really enhance the offer in our education and training programmes," Mark says. "If I'm sitting in an office in Kent, could I train 30 physicists to deal with a radioactive spill? Of course – I could put on a pair of VR glasses, create a situation, 30 people could log in and we could all work together on solving that problem."

Technology also provides many opportunities that professionals have the skill sets to demonstrate and utilise. "AI, big data – physicists and engineers are ideally and uniquely placed to really understand the risks and benefits of some of these technologies and how we implement them into medical pathways," Mark says.

"As President, I will be advocating with the UK government on behalf of our members. For example, there are systems that will do automated diagnoses from chest X-rays. Is it safe to just let the system do that on its own? That is a question I don't think we have answered yet, and that will require changes to our regulations," he says.

Collaboration

With more than 4,500 members and a number of collaborative forums, IPEM is an ideal place for MPCE professionals to collaborate, which is key for the sector to work for better outcomes, Mark points out. "We have Communities of Interest readily accessible, and we can start to build on that engagement across the UK," he says.

Research and innovation play a part too. "We've got engineers and physicists in NHS departments, academic departments, industrial partners. How do we facilitate research and innovation forums so that we get the best opportunities for our members?" he asks.

IPEM also provides a crucial public face for the profession, communicating what physicists and engineers do in the NHS, particularly to universities and schools. "If people study physics at school, do they realise they could go on to become a physicist or engineer in a hospital, and that this is the difference they can make to society?" Mark says.

He is already thinking about what IPEM can do to influence this and how members can get more access to CPD opportunities. "The sheer scope of work for medical physicists and clinical engineers is growing all the time," he says. "Look at a programme like community diagnostic centres – they are springing up all over the place. We have just seen five in Kent and Medway that just weren't there before."

"They all need medical equipment so our clinical engineers will be busy. They all need medical physicists to help them design the radiation protection for those facilities, and to do the work on the medical imaging equipment that they've got, alongside that increasing complexity," he adds.

Building a profile

"The NHS will be spending billions of pounds on workforce development and on implementation of AI and new medical technology. We need to make sure physics and engineering professionals are part of those national strategies," Mark says.

The profession should also be thinking broadly, from a multi-disciplinary perspective, about how technology like AI can support other fields. "People might think that we do medical imaging, assistive technology, radiotherapy, but histopathology is a discipline that will be looking at medical images. And big data can be used to make decisions about health equity – making sure the right patients are getting the right treatment at the right time."

The complexity of the way physicists and engineers deliver treatments and diagnoses today has "changed drastically" since Mark entered the profession thirty years ago. The way AI and technology will continue to transform the medical profession, and the skills they have to guide this, mean medical physicists and clinical engineers must play a leading role.

> **"THE SHEER SCOPE OF WORK FOR MEDICAL PHYSICISTS AND ENGINEERS IS GROWING ALL THE TIME**

Staff profile: Katherine Bunting

I'm IPEM's Director of Education and Professional Development, a role I've taken on after 11 years at the Institution of Engineering and Technology, where I most recently was the Head of Professional Development, leading their CPD, learning and development, initial professional development and mentoring.

IMAGE: ISTOCK

Which elements of your job do you like the most?
I enjoy speaking to our members and volunteers and discovering more about the work that they do. This helps me to shape the plans we have for our training and make sure that the professional development we offer is fit for purpose and changes with the workforce.

What are the biggest challenges you see for your role?
Ensuring that we are able to provide interesting and worthwhile training for all our members, available in a variety of formats, to help support their immediate career and career development.

What accomplishment have you been most proud of in your career?
In my previous role I was able to grow engagement for CPD activities and submission of annual declarations by 60% in two years. To me this was a great demonstration of the shift in members seeing the benefit and importance of professional development.

If you could change one thing about how professional development is perceived within the profession, what would it be?
Helping people to understand that professional registration is achievable and desirable and something which should be encouraged.

IPEM's *Science Leadership Strategy* is identifying and anticipating what might impact the working environment of our members. What are your predictions and how you will help?
As with so many professions, we are not able to fully predict how aspects of AI technology and sustainability are going to impact the way our members work and what skills they will need in the future. So, for me and my team, we need to be ready to offer appropriate training to help facilitate any shifts in skill needs, work with higher education institutions and other academic providers to ensure that those entering the sector have the right grounding and work with colleagues and our licensing bodies to help maintain appropriate standards from registration.

What do you do in your free time?
I am a classically trained soprano and, when I can, I enjoy performing in operas, concerts and other musical ventures. I have performed across the UK in various theatres, cathedrals and venues, but since having children mostly stick with my local church and theatre.

Why should people join IPEM?
Obviously I am going to say there are great professional development opportunities by being a member! However, I would also say that being a member brings you a great sense of community and belonging.

Which IPEM member benefits do you think is the most valuable?
Events and training can really help with your personal development. The work our policy and impact team does can have a big impact on your sector or you may just find the access to our large resources of journals and books helpful and interesting.

***Katherine Bunting** is IPEM's new Director of Education and Professional Development*

HIGHER EDUCATION INSTITUTIONS AND MPCE

Dr Nina Lauvitel, IPEM Workforce Intelligence Manager, looks at the issues at play within the current funding shortfall for education in the sector.

Universities play a critical role in medical physics and clinical engineering (MPCE). They contribute heavily to the training of new clinical scientists and clinical technologists and provide a platform for important advances in research and development to take place. These activities have a clear relationship with improved patient care and efficient use of resources in an increasingly strained healthcare system.

Funding shorfalls

The Campaign for Science and Engineering (CaSE) released a report in July 2024, stating that around 25% of all research activity in the UK takes place at universities. They create research communities that foster collaboration and innovation across many centres and can act as a source of funding for research and development in the context of a strained NHS.

However, funding shortfalls are present across a growing number of universities and higher education institutions across the UK. According to a list maintained by the University and College Union at Queen Mary University of London, there were 67 higher education institutions experiencing redundancies, restructures, reorganisations and closures as of July 2024. In total, 20 of these institutions are home to academic activity in MPCE, in the form of research grants, academic programmes, or centres and institutes. This represents slightly under half of all universities with academic activity in MPCE.

Certain features of MPCE may make these disciplines vulnerable to funding shortfalls. The academic workforce in these disciplines is small. A search covering academic programmes, research centres and grants, and IPEM membership has estimated that there are between 300 and 400 medical physicists and clinical engineers currently working in UK universities. Many of these individuals have joint appointments, also working in clinical and industry settings. The smaller size of this workforce means that budget holders and decision makers may not be fully aware of the important work in these disciplines. Additionally, research and teaching in MPCE are expensive to support, due to the specialised equipment and clinical facilities required. Voluntary severance schemes and departmental closures, therefore, have the potential to significantly impact existing academic activities in MPCE, unless action is taken.

An instrumental contribution

One explanation for funding shortfalls is a reduction in international student numbers, attributable to changes in UK immigration policy. Much research is supported through cross-subsidy from teaching budgets to which international student fees make a large contribution. This is far from being a single explanatory factor: universities benefit from multiple funding streams, with private, public and charitable sources. However, immigration policy is known to impact other areas of MPCE, as the clinical workforce sometimes relies on international recruitment to fill vacancies.

Ensuring access to high-quality training, and robust opportunities for research and development, represent invaluable contributions to MPCE from universities. Although any steps to address current issues will require a complex, multi-faceted approach, it must be acknowledged that universities make an instrumental contribution to high-quality patient care.

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IMAGE: ISTOCK

Member profile: Dr Benjamin Metcalfe

I'm Head of Department of Electronic & Electrical Engineering and Deputy Director of the Bath Institute for the Augmented Human at the University of Bath. I wear many hats, but principally I'm an academic in biomedical engineering and human augmentation.

Tell us about a typical work day?
My core expertise is in neurotechnology and I have developed implantable and wearable devices for interfacing to the peripheral nervous system. In recent years I have moved into leadership positions and most of my time now is dedicated to managing teams, devising and driving strategies and connecting people to maximise the impact that we collectively can make on health and wellbeing.

Which elements of your job do you like the most?
I enjoy enabling and supporting individuals and teams to achieve their ambitions. I have good networks across several sectors and there is nothing better than putting the right people in a room together and watching them build new collaborations and insights that enable a step change in understanding and impact.

What are the biggest challenges you see – either for yourself or the sector?
The higher education sector is in a funding crisis – our primary source of income (tuition fees) has been fixed for home students since 2017 and has devalued with inflation ever since. Concurrently, we have seen costs rise as a result of inflationary pressures and this is a real challenge.

If you could change one thing about the profession or your area of specialty, what would it be and why?
I would really like to break down some of the traditional academic silos. This sounds easy but it requires a fundamental re-think of what it means to be an engineer; we need to deliver the core technical content, but we also need to ensure that sustainability skills are front and centre.

What accomplishment have you been most proud of in your career?
I am most proud of the students, both undergraduate and postgraduate, that I have supervised to graduation. They have gone out into the world and achieved amazing things, from award winning start-ups to promising leadership roles.

What do you do in your free time?
I am an avid reader, both fiction and non-fiction, and I always have at least three books on the go at any one time. At the moment these are (in no particular order): Evelyn Waugh's *Brideshead Revisited*, Ken Follett's *Column of Fire*, and A.N. Whitehead's *Science and the Modern World.*

Why did you join IPEM?
Several colleagues of mine were members, and IPEM seemed like a good fit to my professional experience.

How do you engage with IPEM?
Having previously served as a Member Trustee on the Board, I am currently the Vice-President (Academic) and I sit on several working groups and the President's Advisory Committee.

What does (or should) IPEM do to help you in your career?
IPEM can do different things for different people. For me this has meant that it has given me the opportunity to network well. Aside from academia, I have built impactful collaborations, secured research funding, and shaped policy all because of my time with IPEM.

CANCER TRACERS UNDER THE MICROSCOPE

Will FAPI replace FDG?

Jan Walukiewicz, Senior Clinical Scientist in Nuclear Medicine, looks at pan-cancer tracers for positron emission tomography-computed tomography (PET-CT).

The stalwart pan-cancer tracer of PET-CT, [^{18}F] Fluorodeoxyglucose (FDG), is under threat. Fibroblast activation protein inhibitor (FAPI) is the new tracer on the block, seemingly able to outperform FDG in a plethora of cancers. It has garnered great interest from the scientific and medical communities. This interest is reflected in the 2019 Society of Nuclear Medicine and Molecular Imaging (SNMMI) image of the year – a composite image of ^{68}Ga-FAPI-PET-CT maximum intensity projections demonstrating uptake in 12 tumour types ❷ (see column, overleaf).

Furthermore, the Spring British Nuclear Medicine Society's annual lecture was last year delivered by Professor Markus Hacker and entitled "^{68}Ga FAPI". So, should we be expecting a paradigm shift in PET-CT cancer imaging in the next, say, 10 years?

Working in a different way

FDG uptake is correlated with glucose metabolism, or "fermentation", as was coined by Warburg in 1956. This "Warburg effect" is seen in a variety of cancer cells as they attempt to proliferate, which is typically more than is seen in healthy tissue. FAPI works in a different way. It attaches to fibroblast activation protein (FAP), which is expressed on the cell surface of cancer associated fibroblasts (CAFs). CAFs, and other cell types, make up the tumour microenvironment, which grows with the cancer cells and facilitates cancer proliferation. CAFs cause fibrosis, or scarring, and Dvorak, in 1986, described tumours as "...wounds that do not heal". As over 90% of cancers are carcinomas, and 90% of carcinoma tumour microenvironments contain CAFs, there appears to be an application for FAPI within a variety cancers.

Fibrosis is not just a phenomenon associated with solid tumours, but also other disease types connected to activated fibroblasts. It is generally understood that increased fibrosis is associated with worse clinical outcomes, and FAPI has demonstrated applicability outside of oncology. A wide range of disease types exhibit fibrosis, including rheumatological, and cardiac diseases. It has been shown that there is correlation between the size of atherosclerotic plaques, FAP expression, and FAPI uptake. Another *Scope* article would be required to give justice to introducing FAPI in non-oncological conditions.

Key properties

FAPI and FDG are similar in many respects with a key property being their non-specificity. These tracers are, in general, quite sensitive, but are limited in their specificity. They have, therefore, both shown applicability as pan-cancer tracers, with uptake observed in a wide range of cancers. An advantage of FAPI over FDG is the limited uptake in healthy tissue, such as in the brain, liver and digestive system. This low background has been beneficial in cases such as gliomas (brain tumours) where although the FDG standard uptake value (SUV) is generally greater than is seen with FAPI, the tumour to background ratio

(TBR) is often improved in FAPI imaging.

The non-specificity can be overcome, somewhat, by reporter training. FDG is well understood by clinicians, and their interpretation of images helps combat this non-specificity. It has been shown that experienced reporters of FAPI PET-CT scans have increased interobserver agreement relative to those with intermediate or low experience. It should be noted that although metanalyses have attempted to quantify the specificity of FAPI in heterogenous cancer types, the confidence intervals on these results are large due to the lack of reported true negative data.

An interesting advantage to FAPI over FDG are the theragnostic opportunities. It is not only possible to label FAPI with diagnostic PET isotopes, but also therapeutic, such as ^{177}Lu and ^{90}Y. Although the effective half-life of many FAPI compounds are much shorter than the physical half-life of the isotope leading to poor patient dosimetry, work is ongoing to develop new compounds with prolonged biological half-lives.

IMAGES: SHUTTERSTOCK

"FAPI IS THE NEW TRACER ON THE BLOCK, SEEMINGLY ABLE TO OUTPERFORM FDG IN A PLETHORA OF CANCERS. IT HAS GARNERED GREAT INTEREST

SNMMI IMAGE OF THE YEAR 2019

Each year, the SNMMI chooses an image that best exemplifies the most promising advances in the field of nuclear medicine and molecular imaging. The state-of-the-art technologies captured in these images demonstrate the capacity to improve patient care by detecting disease, aiding diagnosis, improving clinical confidence and providing a means of selecting appropriate treatments. In 2019, the SNMMI Henry N Wagner Jr Image of the Year was chosen from more than 2300 abstracts submitted to the meeting and voted on by reviewers and the society leadership.

The honour went to a team of researchers at University Hospital Heidelberg, Germany that was showcasing the efficacy of the FAPI radiotracer, the image demonstrates the uptake of the FAPI in 12 epidemiological tumour entities, including high uptake values in lung, breast, prostate, esophageal and pancreatic cancer. Low background activity was also observed in the various cancers, resulting in high image contrast and excellent tumour delineation. Also, in contrast to FDG-PET/CT, FAPI-PET/CT can be performed without specific patient preparation after a very short uptake time (~10 mins) and might improve patient comfort and accelerate workflow.

Umar Mahmood, Chair of the SNMMI Scientific Program Committee, said: "Imaging with new tracers such as the one developed – and very nicely demonstrated in this study in a wide variety of cancer types – shows the power of molecular imaging to characterise tumours.

"The image of the year epitomises the great progress made in our field in developing new imaging agents to help optimise cancer therapy for individual patients through such non-invasive characterisation."

Opening the door?

Frustratingly, FDG requires laborious fasting and dietary preparation, with additional difficulties for diabetic patients. FAPI requires no fasting or dietary preparation, and short uptake times of 10 minutes have been demonstrated as equivalent to those of an hour. This opens the doors for dose and scan time optimisation, as well as reducing the number of uptake rooms and increasing scanner throughput. Could this, combined with long-axial field-of-view scanners and low-dose tin filter CT, pave the way for screening and paediatric imaging?

Of the literature reviewed, there appears to be significant positive bias for FAPI, and many authors of key papers have noteworthy disclosures. It is, therefore, refreshing to see examples where FAPI has demonstrated inferior or equal performance to FDG. One study tried to quantify the clinical impact of FAPI vs FDG in a variety of cancers and generally found more positive clinical outcomes in favour of FAPI. Nevertheless, there are serious flaws in this study that significantly limit any conclusions that can be drawn from this. Unless FAPI demonstrates quantifiable clinical benefit, FDG will continue to dominate cancer PET-CT cancer imaging. To achieve this, large studies with homogeneous cancer types are required comparing FDG and FAPI.

Never say never

FDG is part of the standard of care imaging for localised pancreatic disease as recommended by the National Institute for Health and Care Excellence (NICE). However, FDG has limited sensitivity in these cases. FAPI has been shown to have superior sensitivity but poorer specificity in a couple of metanalyses, often due to tumour induced pancreatitis and cholangitis increasing uptake that masks the tumour.

> I BELIEVE THAT ON BALANCE FAPI IS LIKELY TO COMPLIMENT, RATHER THAN REPLACE, FDG

Figure ❶: SNMMI image of the year (2019): FAPI-PET in different kinds of cancer

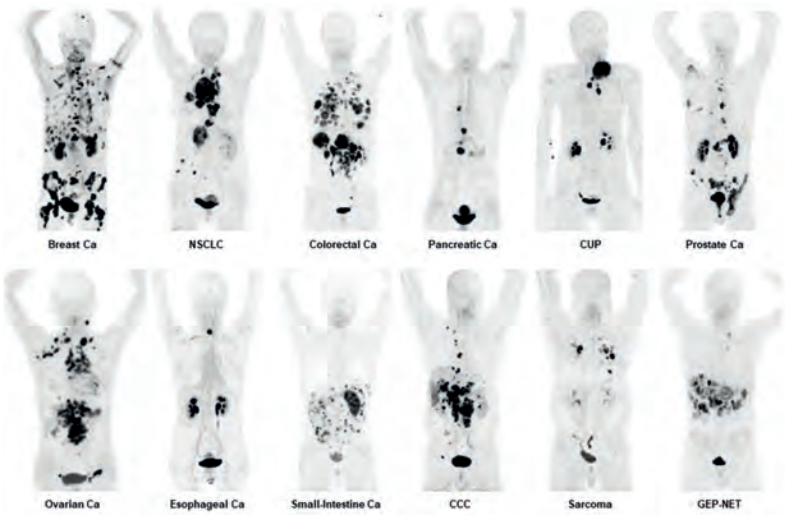


IMAGE: GIESEL ET AL, J NUCL MED, MAY 2019

However, it has also been shown that delayed imaging with FAPI demonstrates a decrease in areas demonstrating this inflammation, but tumour uptake remains constant. This may demonstrate an increase to the specificity of FAPI, which could provide increased clinical benefit relative to FDG in dynamic imaging. This also begs the question, would parametric imaging prove useful here, particularly as localised pancreatic disease would fit within the field of view of current clinical PET-CT systems?

FAPI is (probably) more expensive than FDG and until a ^{18}F FAPI tracer is centrally produced in a similar manner to FDG, the ^{68}Ga FAPI compounds that dominate the international market will be limited to departments with suitable radiopharmacy facilities. Furthermore, within the UK, FAPI is not available clinically and there has been only limited research use. This starkly contrasts the avid international interest seen.

Will FAPI replace FDG as a pan-cancer tracer? Never say never, although I believe that on balance FAPI is likely to compliment, rather than replace, FDG. FAPI provides information on the tumour microenvironment which may reveal additional prognostic information than is currently clinically achievable with FDG. Whether this provides useful clinical benefit has yet to be seen. This, combined with potential therapeutic applications, may allow FAPI to breakthrough into clinical use in the UK.

***Jan Walukiewicz** is a Senior Clinical Scientist working in Nuclear Medicine at The Christie NHS Foundation Trust*

DOSE MANAGEMENT SOFTWARE

Where are we now?

Principal Clinical Scientist and Diagnostic Radiology Special Interest Group member **Michael Barnard** outlines the work behind a dose management software survey and explains the results.

Dose management software (DMS) is an essential tool to optimise radiation doses in medical imaging, ensuring patient safety and regulatory compliance. It automatically collects, stores and analyses patient exposure data from DICOM datasets so that both protocols and patient doses can be monitored. Therefore, we have the tool to optimise but how can we use it effectively? Multidisciplinary image optimisation teams (IOTs) are the answer to making best use of a DMS and ensuring an effective and quality-driven optimisation programme. IOTs are first mentioned in the sixteenth report of the Committee on Medical Aspects of Radiation in the Environment (COMARE) published in 2014 and are further included in the quality standard for imaging. An IOT should include as a minimum:

- Medical physics expert (MPE) – analysis and advice
- Radiographer/technologist – practical aspects of protocols
- Clinician (radiologist/cardiologist/oncologist) – protocols and clinical image quality

It is clear that both DMS and IOTs are important and have been a consideration for NHS trusts for a long time. So where are we now in terms of the use of DMS and setup of IOTs across the UK? How are DMS being used? Who are the main user groups? IPEM and BIR held the first DMS meeting in 2017. The Diagnostic Radiology Special Interest Group (DRSIG) felt it was time to have another DMS meeting to answer some of these questions and this went ahead in Autumn 2023.

To provide some evidence-based discussions during the meeting we set up a DMS survey to find out the prevalence of DMS around the UK, gather data on how they are being used routinely, who is responsible for their maintenance and how many centres have an IOT. We hoped that by capturing and sharing regional information about what DMS is used

IMAGES: SCIENCE PHOTO LIBRARY

where, this would help with collaborations between sites and ensuring we are making the best use of these tools.

Survey design

Microsoft forms was used for the survey and a link shared on IPEM's Communities of Interest and the MPCE jiscmail list. The survey was open between 7 August and 1 September 2023. The list of questions is shown in table ❶. The survey captured the responders' trust information and which DMS is used in order to remove possible duplicates. It was also asked if the response could be used for assessing regional coverage. Data on how the DMS is used and for which modalities was captured. This included details of the staff groups responsible for the implementation and maintenance of the software. The final two questions captured data on how many trusts had an IOT and a free text section to capture any interesting comments. If only I had read Russell Dawson's *Scope* article regarding text free responses!

Table 01: Survey questions

What services does the submission answer?
What trusts do these answers cover – spotting duplicates?
Can we use your response to assess regional coverage?
Which DMS do you use?
If routinely used for optimisation - what modalities do you use it for?
If routinely used for effective dose estimation - what modalities do you use it for?
Who is/was responsible for the implementation and maintenance?
Do you have a formal IOT?
Is there any further information you would like to share on how the DMS is being used that is not included above or any further comments regarding implementation/maintenance

Findings of the survey

We received 52 responses covering 54 trusts and health boards. In Figure ❶, 93% of the trusts included radiology in the return, 37% included cardiology, 17% included radiotherapy (two trusts included radiotherapy only). A total of two trusts specifically mentioned nuclear medicine.

DMS coverage: The type of DMS employed by the 54 trusts is shown in Figure ❷. Qaelum DOSE, OpenREM and Siemens Healthineers Teamplay are the most prevalent DMS in the survey. Comments were received regarding the difficulty in procuring a DMS whereby trusts refuse to purchase commercial systems or ones not included in a PACS refresh. OpenREM is an opensource DMS and so the software is free and a version of Siemens Healthineers Teamplay that can only be used with

> **MANY CENTRES LOOK AT FREE OPTIONS, BUT THEN THE SKILLS AND RESOURCES FOR IMPLEMENTATION ARE LACKING**

Siemens equipment is also free. From survey comments, many centres look at free options, but then the computing skills and resources for implementation are lacking and projects do not move forward. It is also noted that IT departments may not allow opensource software. A total of 4% of the trusts in the survey use an inhouse DMS and 7% of the trusts do not have a DMS or are currently planning/procuring one. In Figure ❸, one trust looks after three DMS while the majority (82%) have only one.

Routine use: In total, 66.6% of the respondents use the DMS for optimisation, with CT being the highest modality (65%) – Figure ❸. Trusts will be prioritising high-dose modalities, but this may also reflect the ease with which the modality can be set up for a DMS. If radiation dose structure reports (RDSRs) are not available, dose sheets can still be utilised, and useful dose information can be captured. Important parameters will also be captured in the DICOM information. If RDSRs are not available for fluoroscopy and interventional equipment, this can make capturing robust dose and protocol information difficult.

A further question was asked on whether the DMS is used for calculating/providing effective dose, Figure ❺. A total of 31% responded to using DMS for estimating effective dose but from the comments, this was mainly patient dose metrics exported from the system and used. Most versions of commercially available DMS have effective dose calculators or use conversion factors that can be edited by the user. Exporting data from a DMS is a key theme noted and was discussed at the DMS event. The intention of the question was to establish whether the effective dose, reported in the DMS, was routinely used e.g. for incident reporting. This was however unclear in the responses and a pilot survey would have helped resolve such issues prior to the main survey being launched.

IOTs: As described in the introduction, IOTs are a key factor in making the most of the data captured by a DMS. In total, 66.6% of the respondents had an IOT, with comments describing variation in modality implementations and stages of setup. For example, the resources used to set up a formal CT IOT then leaves insufficient resources to implement other IOTs.

> **"WE NEED REGULAR SHARING BETWEEN CENTRES AND TO REQUEST USER GROUPS THROUGH DMS VENDORS**

Who uses it?: The final question before general comments was related to which departments implement and maintain the DMS. From the survey comments it is recognised that the maintenance of the system requires significant staff time for tasks such as adding new equipment, adding new users or dealing with server downtime and processing problems. Several comments indicated that most of this activity is the sole responsibility of the medical physics team and that this could be further impacted by the type of DMS. Particularly if the trust will not purchase a DMS and so to reduce costs, open software is used, requiring significant resources and skills to implement.

Review of the comments also picked out a few common themes, one of which was the cost associated with adding new equipment to send to a DMS. The cost to add a new DICOM node to equipment can be expensive if it cannot be completed by the user. At my centre, PACS nodes/relays are used to forward studies to our DMS automatically and so no intervention is required by the manufacturers. In the same vein, old equipment that cannot send the preferred DICOM dataset such as an RDSR are not included in the DMS and other means such as radiology information systems are used instead to capture the basic data. One trust in the survey did describe a formal group within medical physics that work on DMS user level activities such as adding new users and new equipment.

DMS event

The DMS event was held on 4 October 2023 in Manchester – exactly six years to the day from the last meeting. Results were presented to the audience and an interactive session was set up to focus on IOTs, how different centres set them up, how often do they meet, which modalities and which roles are included. In my experience, IOTs are invaluable and ensure the best use of the DMS and ultimately facilitate the optimisation task. However, radiologist engagement is often poor due to their clinical workload and this is reflected in the outcome themes from the interactive session:

Successes

- Regular meetings help with engagement
- Communicating results
- Using image audit meetings as springboard – dose audit presented by medical physics
- Radiologist pure engagement with IQ
- Presenting specific dose audit results to radiologist
- Inclusion of reporting radiographers
- Utilising the right tools (DMS, phantoms and staff).

Barriers

- Lack of time and staffing
- Radiologist engagement
- Merge trusts difficult to standardise.

At my centre, the IOT feeds into a medical radiation exposures committee (MREC). Dose survey data is used at the IOT to determine the strategy for the coming months or year and these reports together with annual patient numbers help the team to prioritise projects. We are also in the process of adding all CT protocol information in to our DMS so that it is all available in one location, facilitating the optimisation and standardisation process. This work has significantly increased engagement of radiology with the DMS and communicating optimisation successes through a IOT effectiveness report has

meant visibility to senior management within the trust. This work alongside a sharepoint site describing the IOT and its current work and outputs will help make the IOT more visible and hopefully increase engagement from clinicians.

Final Thoughts

As a community we have moved on from the initial implementation steps taken and shared in 2017 for the first DMS meeting. There is a large resource of knowledge and experience from both physics colleagues as well as those involved clinically and these need to be shared on a regular basis. We need regular sharing between centres and to request user groups through DMS vendors to make the best use of DMS and to share successes. What is clear from the survey data, discussions and feedback is that the currently available DMS do not fit with what we want as a community. Many centres use a DMS for data capture and export to feed into separate analysis, with some implementations requiring significant physics resources.

I have suggested to IPEM and the DRSIG that a DMS meeting with representation from developers should be a regular occurrence in the event diary, with suggestions of annually (44%) and biannually (40%) meetings being the top two options in the meeting feedback. The AAPM currently has a task group creating guidance on the selection, implementation and management of DMS and this would be a significant step forward for centres looking to procure such systems. There is a disparity in current guidance available and the use of DMS in patient dose audits and considering the information gathered for the DMS meeting, there may be justification for an IPEM Working Party to develop best practice on the use of DMS.

Michael Barnard *is Principal Clinical Scientist in the Imaging Physics and Radiation Protection Group at Oxford University Hospitals NHS Foundation Trust.* *He would like to acknowledge Laurence King and Ed McDonagh (survey design), Ruth Bradley (proof reading) and Angus Fraser (data analysis).*

Figure 1 Departments represented by respondent

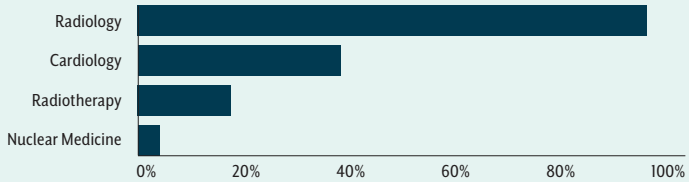


Figure 2 Usage of different DMS

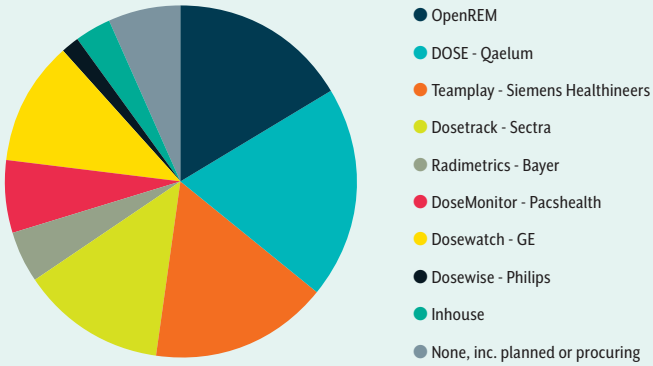


Figure 3 Number of DMS employed by respondent

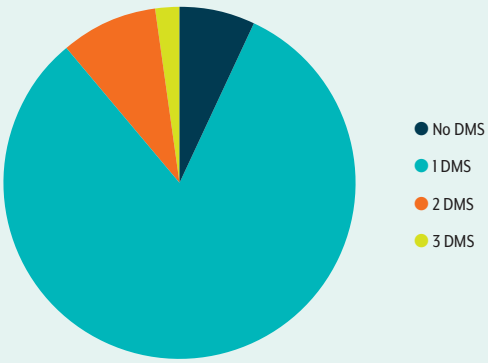
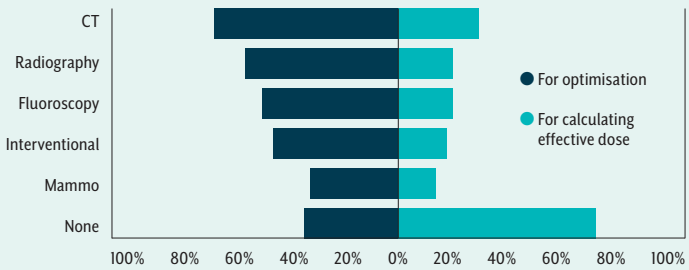
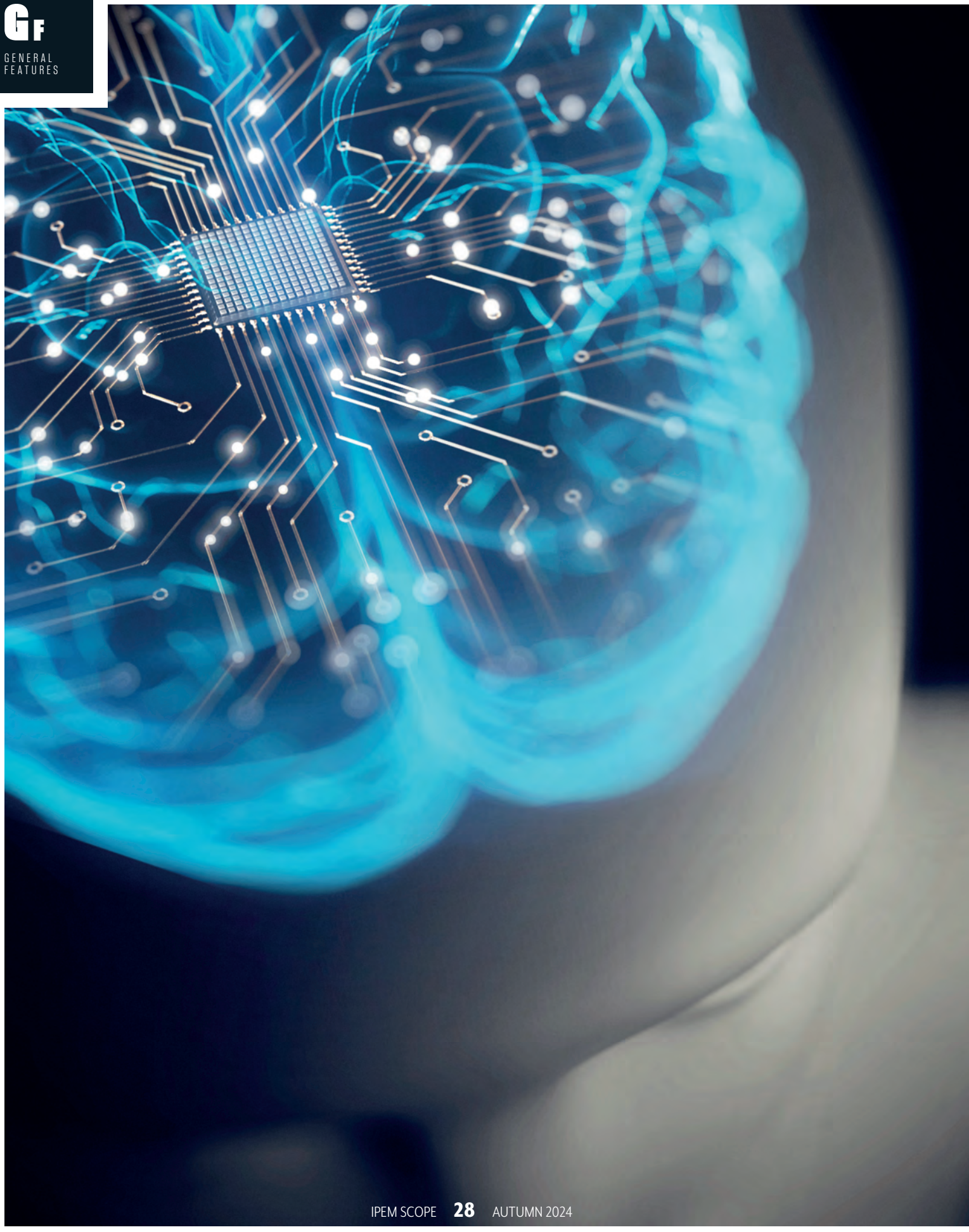


Figure 4 and 5 Modalities where DMS is used





ARTIFICIAL INTELLIGENCE IN HEALTHCARE

What is our role as medical physicists?

Alison Starke and **Lydia Davidson**, Committee members of the IPEM AI Working Group, discuss a new IAEA publication.

The role of a medical physicists has many facets – should the validation of clinical artificial intelligence (AI) systems be one of them? The International Atomic Energy Agency (IAEA) seems to think so, having recently published *Artificial Intelligence in Medical Physics* as part of its training series. It covers the roles, responsibilities, education and training of medical physicists working on the implementation of AI in medical specialisms involving radiation. It is very timely given the recent AI "boom" and the technology having found its way into many areas of medicine.

AI is commonly reported as something which can revolutionise healthcare. The possible applications of AI in radiation oncology, diagnostic imaging and nuclear medicine are vast and exciting. However, it can be dangerous if implemented by people who don't have a good understanding of AI and its potential risks. Professionals working with this area therefore need sufficient AI-specific training for it to be adopted safely.

Where do medical physicists fit in?

We are used to bridging the gap between new technologies and the needs of the clinic – the IAEA suggest we should think of AI as another technology and that we have a vital role to play in the integration of AI in radiation healthcare. This sounds exciting, but perhaps a bit daunting. What does it involve and do we feel equipped to do so?

This publication looks to define the role and responsibilities of medical physicists in the application of AI in radiation medicine and provide guidance for education and training competencies. We have summarised them here.

Roles and responsibilities

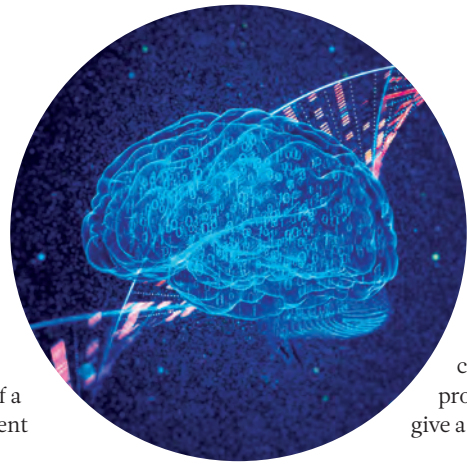
The IAEA identified six core areas a physicist should be responsible for. These are activities we already do when introducing other technologies into our clinics, perhaps making it a bit less intimidating, and showing us that we already possess many of the generic skills required:

- Development of technical specifications for AI procurement
- AI acceptance and commissioning
- Optimisation of the physical aspects of medical procedures
- Quality management of the AI-based tools
- Education and training of other healthcare professionals
- Scientific research and development.

The document discusses each of these in details and how they relate to AI systems.

Technical specifications: We should be involved in identifying potential vendors, preparing functional specifications, participating in tender evaluation, ensuring the software complies with legislation and guidelines and helping to evaluate the different AI solutions.

Acceptance and commissioning: We will be involved in acceptance testing to ensure the software complies with the vendor's specifications. We would also lead the evaluation of the system, and ensure acceptance and commissioning tests are repeated when the AI model is updated in the future.



Optimisation: For diagnostic and therapeutic procedures involving AI, the medical physicist will collaborate with the practitioner to assess the efficacy of an AI tool, as well as evaluate image quality if this is applicable. They will also work together to ensure safety of the processes is optimised.
Quality management: We will work as part of a multidisciplinary team to design and implement a quality management programme. This will include writing a risk assessment prior to using the AI software clinically, working with the clinical team to write protocols for its clinical use and establishing a QA programme. We also need to ensure the QA programme includes testing when changes are made.
Education and training: Medical physicists will take part in CPD specific to AI so that they have sufficient theoretical knowledge to ensure its safe and effective use. This will give the necessary expertise to train other members of the clinical team, ensuring they are aware of the presence, risks and limitations of any AI algorithm they are using.
Research and development: AI in hospitals is currently at the early stages of adoption. Consequently, it offers many research and development opportunities. Examples of work include evaluating the clinical performance of existing AI systems, looking into improving existing models or being involved in designing totally new models. This field has lots of research potential for our profession.

How do we get ourselves sufficiently trained?

The IAEA recognise that although we already have lots of the generic skills required to fully undertake these responsibilities, it is vital that we, as a profession, acquire sufficient basic knowledge of AI. This is not something that has historically been included in our training so must be addressed. The IEAE acknowledges this training gap and suggests a two-pronged approach: one for those joining the profession in the future, and another for current medical physicists.
Postgraduate medical physics academic programmes: The first tackles trainee physicists who are undertaking a postgraduate medical physics qualification and recommends that educational institutions incorporate an AI-specific academic module. This should include the theoretical fundamentals of AI as well as practical sessions to give students hands-on experience. They advise teaching basic AI theory, risks specific to AI algorithms and how to safely use programmes containing AI algorithms. The suggested practical sessions include having the students train and evaluate AI models.

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> **IT IS EXCITING AS A PROFESSION TO BE SEEN AS ONE OF THE KEY PLAYERS REQUIRED TO DEPLOY AI TOOLS**

Ongoing training for current medical physicists: The second approach addresses already qualified physicists and recommends a programme of CPD activities and online resources to close the knowledge gap. The document goes into detail about the advised course content for the proposed CPD programme and academic module that would give a medical physicist sufficient knowledge to work effectively with AI software. Again, they suggest the courses should provide an insight into the theory of AI, along with discussing the potential challenges of integrating, commissioning, validating and deploying models safely into our clinical workflows.

Our take on the publication

Artificial Intelligence in Medical Physics lays down the IAEA's vision of the role of a medical physicist in AI in healthcare and clearly states the importance of our role within this emerging field. It also details how we can get ourselves sufficiently educated to perform this safely and effectively. The reader should not, however, expect step-by-step guidance on executing the responsibilities. For example, there are limited suggestions in the document as to how a medical physicist should carry out quality testing on a clinical AI system. What the publication does especially well is give an overview of the key risks associated with clinical AI-based tools. The risks outlined can help guide future conversations with vendors and clinicians using the software, as understanding the risks and limitations of an AI tool is the first and most important step in its safe use and management.

Validating clinical software has typically been one of the many items on a medical physicist's job description, and so to have bodies like the IAEA extend this to AI is a logical step.

It is exciting as a profession to be seen as one of the key players required to deploy AI tools safely in our clinics and we think it is timely that this review has come out to open a discussion around how we can get ready for this potential expansion of our roles. Exactly how this will play out in the UK has yet to be decided, however, this publication is one of the first steps towards navigating the shifting landscape of this exciting new technology in healthcare.

Alison Starke *is a Principal Radiotherapy Physicist at Barts Hospital in London.* ***Lydia Davidson*** *is an Imaging Physicist at the Royal United Hospital in Bath. For more information and to download a PDF of Artificial Intelligence in Medical Physics, visit* ***b.link/5zulul1u***

REPETITIVE TRANSCRANIAL MAGNETIC STIMULATION

A real-world evaluation

A team from the **TriTech Institute** discuss a trial of a non-invasive neuromodulation for the treatment of psychiatric illnesses.

Repetitive transcranial magnetic stimulation (rTMS) is a non-invasive, non-convulsive form of neuromodulation used for the treatment of psychiatric illnesses. It is based on the principle of electromagnetic induction. Magnetic fields are generated by passing rapidly alternating electrical currents through a coil with a ferromagnetic core. The magnetic field generated by the TMS device varies from 1.5 to 3 Tesla, comparable to that of an MRI machine. The magnetic pulse is applied to a small, focused area of the brain to result in cortical stimulation. The common area of stimulation is the left dorso-lateral pre-frontal cortex (LDLPFC). The pulses can be delivered in a rapid (1-20Hz) repetitive fashion, increasing the cortical activity or in a slow (<1Hz) repetitive fashion, inhibiting cortical activity.

Emerging evidence

rTMS has been shown to be a well-tolerated procedure with minimal side effects. rTMS is an effective treatment option for patients with depression who have not benefitted from antidepressant treatment. It received food and drug

administration (FDA) approval in 2008 and since then has been used widely in the US. The National Institute for Health and Care Excellence (NICE) renewed its guidance for use of rTMS in 2015, noting no major safety concerns and evidence of short-term efficacy supporting its use as treatment for depression. rTMS treatments are being used in England NHS trusts, but currently not in Wales. The strongest evidence base available is in the treatment of depression, but there is an emerging evidence base for its use in other psychiatric disorders such as anorexia nervosa and post-traumatic stress disorder (PTSD).

A pilot in Wales

Hywel Dda University Health Board (HDdUHB) is one of seven NHS university health boards and trusts in Wales. It provides primary and secondary care services for residents within its borders in the counties of Carmarthenshire, Pembrokeshire and Ceredigion. Glangwili General Hospital (GGH) is the biggest of the health board's four acute hospitals, with approximately 320 beds to provide inpatient services for patients across the region. The pilot HDdUHB rTMS service was run from GGH overseen by the Consultant Liaison Psychiatrist and Consultant Nurse within the mental health and learning disabilities (MHLD) department. The team's oversight ensured no treatment was withheld or started inappropriately and good clinical practice was followed throughout. The service was available five days a week, the treatment sessions took place on a Monday and ran consecutively Monday to Friday. Sessions were scheduled five days a week for approximately four to six weeks, however, the provision for rTMS was limited during bank holidays. The clinic used the Magstim Rapid Plus machine and to monitor the safety and acceptability of the service, a concurrent service evaluation was undertaken.

Aims and plan

The evaluation intended to answer two questions with regards to rTMS: Can rTMS be safely implemented as a service within NHS Wales? And is it acceptable to patients and staff?

A mixed-methods approach was utilised to meet the aims of the evaluation via the objectives and outcomes set out below. The evaluation was led by the TriTech Institute as part of HDdUHB, with funding from Life Sciences Hub Wales (LSHW). The loan device and clinical training was provided by Magstim. The patient facing component of the evaluation was handled directly by the MHLD team and the evaluation was coordinated by the team at the TriTech Institute. The service evaluation period was three months, with a start date of 10 January 2022.

Methodology

The clinical data was collected by the MHLD team at routine rTMS appointments, at baseline, and then repeated at weeks two, four and six. The validated tools used to measure clinical outcomes were:

BDI II (Beck Depression Inventory) – 21 groups of statements, for each group with the instruction to circle the statement that best describes the way a person is feeling. A higher score will indicate increased depression.

PHQ-9 (Patient Health Questionnaire) – includes nine statements that are scored between (0 = not at all) to (3 = nearly every day). An increased score indicates higher severity of depression.

MADRS (Montgomery Asberg Depression Rating Scale) – used by clinicians to assess the severity of depression among patients with a diagnosis of

"PATIENTS WHO HAD EXPERIENCED ECT TREATMENTS IN THE PAST PREFERRED RTMS

depression. It is designed to be sensitive to change resulting from antidepressant therapy. Increased scores indicate higher severity of depression.

CGI (Clinical Global Improvement Scale) – used as an efficacy measure of a given treatment.

A questionnaire, along with an evaluation patient information sheet (PIS), was used to gather patient feedback. Patient feedback was obtained after the 20th session, which usually coincided with the fourth week of treatment. The patient feedback questionnaires had three sections, each with statements that asked the patient for their level of agreement or disagreement. The questions were divided into three sections:

- Physical comfort,
- Impact of treatment
- Understanding of treatment.

Findings

Over the course of the rTMS pilot, the average clinical scores improved for the majority of patients from baseline to six week review:

- Beck Depression Inventory (BDI II) – 7 out of 10 patients showed an improvement in scores.
- Patient Health Questionnaire (PHQ-9) – 7 out of 10 patients showed an improvement in scores.
- Montgomery Asberg Depression Rating Scale (MADRS) – All 10 patients showed an improvement in scores.
- Clinical Global Improvement Scale (CGI) – 7 patients showed minimal improvements, 1 patient was "much improved", 1 patient was "very much" improved, and 1 patient showed no change.
- 9 out of 10 patients completed the service evaluation questionnaire.
  - **Physical comfort** - This statement had a varied response: 4 (44.4%) felt no discomfort, 2 (22.2%) felt neither and 3 (33.3%) felt some discomfort.
  - **Impact of treatment** - This was a varied response, 3 (33.3%) reported no negative effect: 2 (22.2%) gave a neutral reply and 4 (44.4%) indicated a negative effect.
  - **Understanding of treatment** - This was a positive result: only 1 (11.1%) of patients felt unclear about the treatment after the explanation, 1 (11.1%) was indifferent and the rest 7 (77.7%) of patients said they understood the treatment after the explanation.
  - **Patients who had experienced ECT treatments** in the past preferred rTMS.

> **"FURTHER WORK SHOULD BE CONDUCTED TO EXPLORE THE CLINICAL BENEFITS FOR OTHER CONDITIONS**

Conclusion

Patients who had experienced ECT treatments in the past preferred rTMS, with clinical benefits demonstrated in some patients. However, the cost effectiveness, impact on staff and service time as well as the longer-term clinical benefits need further analysis before rTMS is moved into routine clinical care within HDdUHB. The evaluation concluded the following recommendations.

Recommendation 1- Further work should be conducted to explore the clinical benefits for other conditions and symptoms such as anxiety disorder, OCD and suicidal thoughts. Other treatment protocols, such as theta burst, should also be explored in determining patient throughput, service efficiencies and clinical effectiveness.

Recommendation 2 - Future work should include a robust economic analysis (over the long term) and cost-benefit value to assess the possibility of introducing rTMS as part of routine services.

Chris Hopkins, Billy Woods, Rachel Gemine, Akhtar Khan, Richard Jones, Arya Chandran *are from The Tritech Institute at Hywel Dda University Health Board. There were no commercial or financial relationships that could be construed as a potential conflict of interest.*

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GA-68 IN PET IMAGING

A rising star

Nuclear Medicine Technologist **Clara Ferreira** looks at the potential for a promising alternative to Technetium-99 metastable.

In recent years, the field of nuclear medicine has witnessed significant advancements in imaging techniques, particularly with radiotracers. Among these, Gallium-68 (Ga-68) has emerged as a promising alternative to the widely used Technetium-99 metastable (Tc-99m). We will explore the potential of Ga-68 to replace Tc-99m, evaluating its advantages, clinical applications and challenges. The versatility and effectiveness of Ga-68 have opened new avenues in diagnostic imaging, making it a subject of great interest among researchers and clinicians.

The Rise of Ga-68 in Medical Imaging

Ga-68 is a positron-emitting radionuclide with a half-life of 69 minutes, making it suitable for positron emission tomography (PET) imaging. Its use has been particularly notable in the imaging of neuroendocrine tumours (NETs) and other malignancies due to its superior imaging capabilities and availability. The development of Ga-68-labeled compounds has revolutionised PET imaging, offering high-resolution images that are crucial for accurate diagnosis and treatment planning.

Advantages of Ga-68 over Tc-99m

Superior image quality: One of the primary advantages of Ga-68 is its superior imaging quality – providing higher spatial resolution and sensitivity compared to the single-photon emission computed tomography (SPECT) with Tc-99m. This enhanced imaging capability allows for better tumour localisation and characterisation, which is crucial in the management of cancers such as neuroendocrine tumours. The precision of Ga-68 PET imaging helps in detecting smaller lesions, which might be missed by conventional imaging techniques, thereby improving the overall diagnostic accuracy.

Shorter half-life: Ga-68's shorter half-life is beneficial for reducing patient exposure to patients. This is particularly advantageous in paediatric imaging and follow-up scans where minimising radiation dose is essential. This factor makes Ga-68 a safer option for repeated imaging, which is often required in chronic conditions and during long-term monitoring of disease progression.

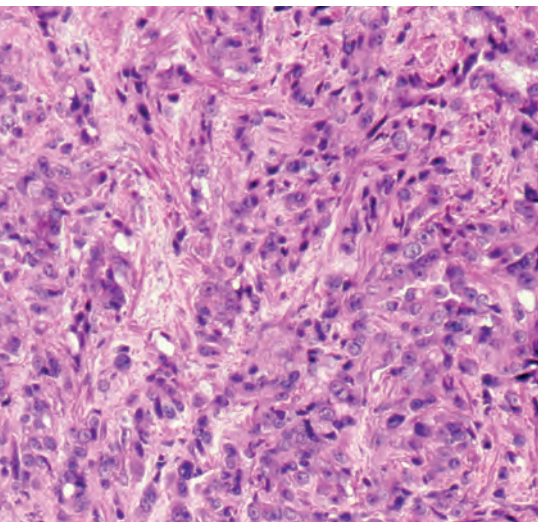
Enhanced specificity: Ga-68-labeled compounds, such as Ga-68-DOTATATE and Ga-68-PSMA, have demonstrated higher

specificity for certain receptors and antigens. For instance, Ga-69-DOTATATE bins specifically to somatostatin receptors, which are overexpressed in NETs, providing more accurate diagnostic information. This specificity reduces false positives and enhances the clinician's ability to make informed decisions regarding patient management.

Clinical applications of Ga-68

Neuroendocrine tumours: Ga-68 has become a game-changer in the imaging of NETs. Ga-68-DOTATATE PET-CT has largely replaced traditional imaging, such as In-111-pentetreotide SPECT-CT due to its superior sensitivity and specificity. Studies have shown that Ga-68-DOTATATE can detect NET lesions with higher accuracy, leading to better staging and treatment planning. The ability to detect both primary and metastatic lesions accurately allows for more effective treatment strategies and monitoring of therapy response.

Prostate cancer: Ga-68-PSMA is increasingly used for the detection and staging of prostate cancer. Prostate-specific membrane antigen (PSMA) is highly expressed in prostate cancer cells and Ga-68-PSMA has shown superior performance in detecting both primary and metastatic lesions compared to conventional imaging method. This has significant implications for the early detection and management of prostate cancer, potentially leading to better patient outcomes.



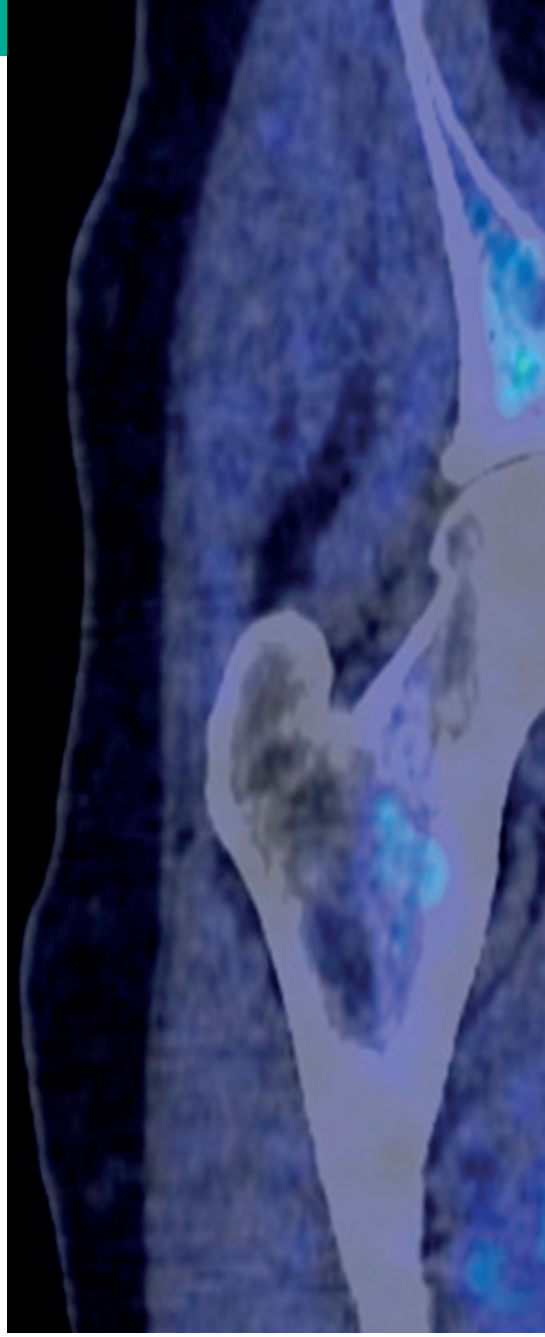
> "THIS ENHANCES THE ABILITY TO MAKE INFORMED DECISIONS FOR PATIENT MANAGEMENT

Infection imaging: Ga-68-citrate has shown promise in the evaluation of infections, particularly in cases of osteomyelitis and prosthetic joint injections. It offers the advantage of detecting both soft tissue and bone involvement with high accuracy. The ability to pinpoint the exact location and extent of infection helps in tailoring appropriate treatment plans and monitoring the effectiveness of interventions.

Challenges and considerations

Production and availability: One of the significant challenges with Ga-68 is its production and availability. Ga-68 is typically produced using a Ge-68/Ga-68 generator, which has a limited supply and requires regular replacement. This can limit the widespread adoption of Ga-68 in clinical settings. Efforts are ongoing to improve the production methods and increase the availability of Ga-68 to meet the growing demand.

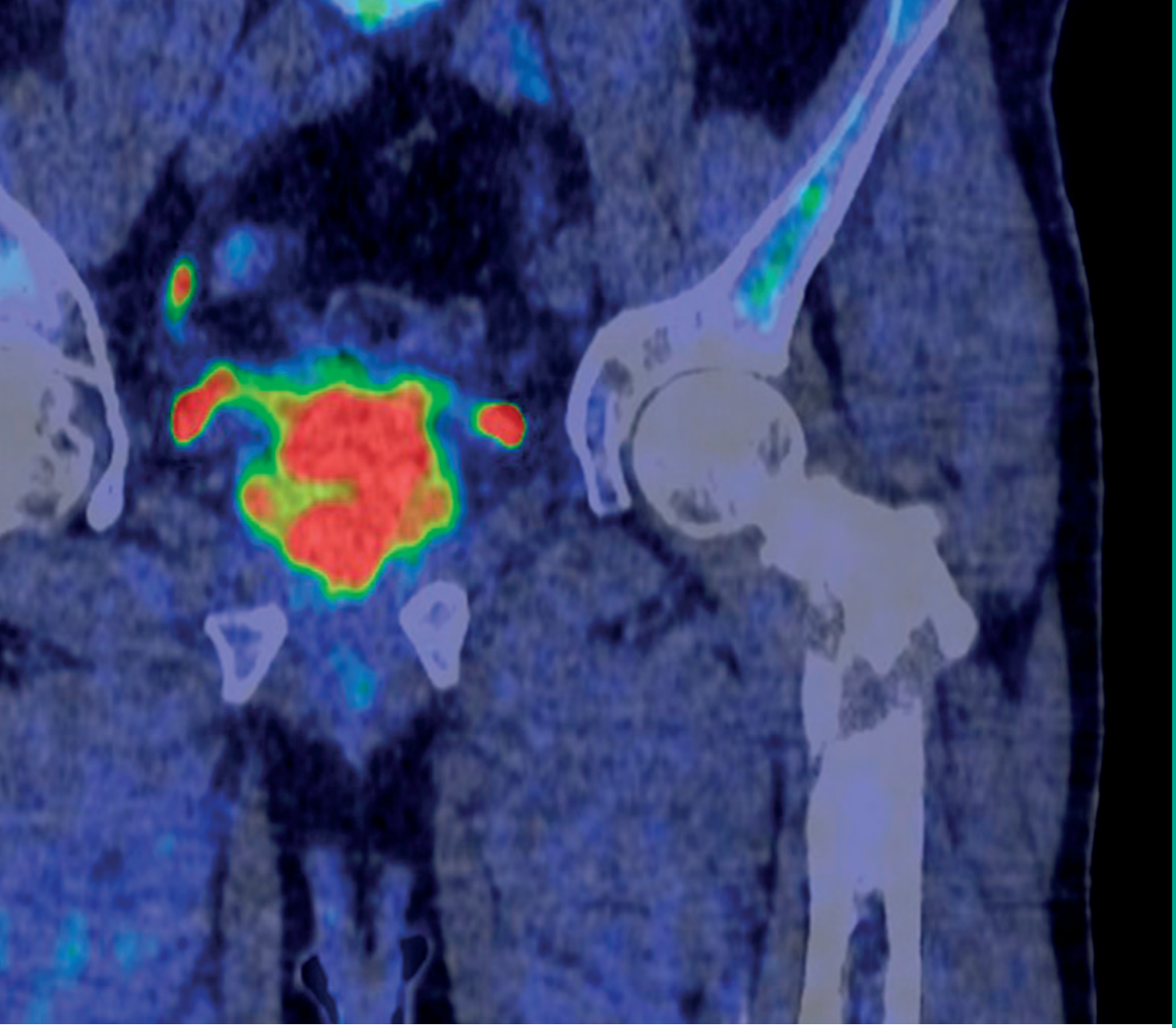
Cost: The cost of Ga-68 scans can be higher than Tc-99m SPECT scans due to the complexities involved with Ga-68 production and quality control. This can be a barrier, particularly in resource-limited settings. Collaboration between researchers, clinicians, and regulatory agencies is necessary to streamline the approval process and bring innovative imaging agents to clinical practice.



Future prospects

Expansion of Ga-68 applications: The future of Ga-68 in medical imaging looks promising, with ongoing research exploring its use in various other cancers and diseases. The development of new Ga-68-labeled compounds targeting different receptors and biomarkers could further expand its clinical applications. Innovations in radiochemistry and molecular imaging are expected to enhance the versatility and effectiveness of Ga-68 PET imaging.

Improvements in production technology: Advances in generator technology and alternative production methods could



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improve the availability and reduce the cost of Ga-68. This would facilitate its broader adoption in clinical practice, making high-quality PET imaging accessible to more patients. Investment in research and development is crucial to overcome the current production challenges and ensure a steady supply of Ga-68 for clinical use.

Integration with other imaging modalities: Integrating Ga-68 PET-CT with other imaging modalities such as MRI could provide comprehensive diagnostic information, enhance the accuracy of disease characterisation and treatment planning. Multimodal imaging approaches can offer a more detailed and holistic view of the disease, aiding in precise diagnosis and personalised treatment.

Conclusion

Ga-68 has demonstrated significant potential as a replacement for Tc-99m in various diagnostic imaging applications. Its superior imaging quality, shorter half-life, and enhanced specificity make it a valuable tool in the management of NETs, prostate cancer and infections.

While challenges such as production, cost and regulatory approvals remain, ongoing research and technological advancements are likely to address these issues, paving the way for the widespread adoption of Ga-68 in clinical practice.

The future of nuclear medicine looks bright with Ga-68 at the forefront, promising improved diagnostic accuracy and better patient outcomes. As the field continues to evolve, Ga-68 is expected to play an increasingly vital role in advancing medical imaging and improving patient care. However, Tc-99m remains a valuable tool due to its wider availability and cost-effectiveness; both radioisotopes have unique advantages and disadvantages that make them suitable for different applications.

Clara Ferreira *is a Nuclear Medicine Technologist working for NHS England*

LINAC QUALITY CONTROL

Risk management to improve safety and efficiency

A team from **Hull University Teaching Hospitals NHS Trust** looks at applying risk management techniques in linac quality control.

A robust linac quality assurance (QA) programme is key to ensuring the safe delivery of radiotherapy. Professional bodies provide guidance as to which quality control (QC) tests should be completed and at what frequency; however, this guidance can quickly become out of date. This is particularly apparent with linacs, where technology develops rapidly. Despite the latest version of *IPEM Report 81* being published in 2018 it does not include linac QC for routine techniques such as gated treatments. The UK guidance attempts to cover the majority of equipment in radiotherapy, resulting in large reports that are not frequently updated, and includes content that is not always model specific, meaning a local adaptation is more appropriate.

The AAPM Task Group 100 recognised this issue and suggested that local centres should produce their own specific QC protocols based on the local situation using risk analysis methods such as "failure mode and effect analysis" (FMEA). This was also discussed in *IPEM Report 81* as an alternative approach.

Failure mode and effect analysis

FMEA is a risk analysis technique that encourages a team to work together to identify what can go wrong (failure mode) in a process, how badly (severity), how often (occurrence) and how likely it is to be identified (detectability). These are combined into a risk prioritisation number (RPN) to allow comparisons between failure modes. In essence, it is an elaborate risk assessment. We used this as a framework to structure our discussions on how the equipment may fail. QC was then added into the system as a mitigating event, typically to improve detectability, and additional interventions to reduce occurrence. We wanted to build a QC protocol based on what could go wrong with a linac, so we used FMEA as a framework, starting with our TrueBeams system.

A known limitation of techniques such as FMEA is "failure of imagination". If you do not think of something as a failure mode, you will not consider it a risk. This highlights the importance of the local, national and international reporting of incidents. To increase the chance of including as many failure modes as possible, we assembled a team of experienced physicists and technicians that met on a weekly basis to discuss all the possible ways that we believed a TrueBeam linac could fail. We continued to meet as a team to score the failures for severity, occurrence and detectability and to add QC.

To focus our thought process, we split the TrueBeam up into 11 processes: beam production, gantry motion, collimator motion, accessory, respiratory gating, imaging, complex modulation, isocentre, network, couch and miscellaneous. We assumed that no QC was being completed at all, and the only controls were interlocks and those mandated by the manufacturer as part of the support contract. This meant that we were able to build the foundations of a QC protocol based on risk with no bias to the current tests completed.

Define the cause

FMEA requires you to define the cause and effect of each failure. Initially we considered the failure mode effect as the impact to the linac output. However, this resulted in lots of similar failure modes that were difficult to score individually. Instead, we changed to consider the failure mode effect as the impact to the patient. This simplified the process significantly and became much more intuitive. Although we tried to be

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Figure ❶ The actions taken in the risk management process

as quantitative as possible, we soon realised how subjective scoring was going to be. We used several cycles of scoring to try to ensure consistency and that each failure was reasonably scored relative to the others. We added detailed comments to each score so that our rationale was recorded for future review. The benefit of us scoring as a team was that we could use our collective experience. We found limited consistency when comparing published scores. This shows that FMEA is not one-size-fits-all and care should be taken if applying external scoring locally.

We defined severity as the harm to a patient. This included inconvenience, radiation mistreatment and physical harm, which may range from 1 to 10, with 1 being an incident with no effect and 10 being catastrophic injury or death. The most common inconveniences were delays in treatment, which were scored at a 2 or a 3. A score of 3 was used for an event that may require repeat imaging. Due to the fail-safe nature of the TrueBeam control systems, this covered many of the failure modes.

We have four TrueBeam linacs in our department, equating to 25 machine years of experience dealing with breakdowns and out-of-tolerance QC results. Where possible we based occurrence on known events. When this was not possible, we estimated the occurrence based on our understanding of the TrueBeam and the safety features included. We reviewed all our TrueBeam QC results and found very few failures detected by testing as a TrueBeam tends to fail-safe. However, we did identify some drifting parameters, which were corrected before tolerances were exceeded. For this reason, occurrence was probably the most difficult parameter to score and tended to have a low value.

Failures

Detectability, or lack thereof, was scored based on how likely the failure mode was to be identified if it did occur. Any event that had a clearly observed failure state, such as the machine not being able to produce a beam, had a detectability value of 1. Initially detectability was scored based on how likely a failure was to be identified if no QC was being performed. This resulted in detectability primarily being scored either a 1 or a 10.

If the resulting RPN score was unacceptably high, we added in a QC test at a frequency that would reduce the detectability score. Forty was the lowest RPN that could be reasonably achieved following calibration and commissioning therefore we used this value as a benchmark when adding QC. Other RPN limits have been suggested in literature however, as the scoring is so subjective, these should only be applied if following the exact same scoring methodology.

Calibrations are a key point of failure as secondary and tertiary systems are reset. If the calibration is performed incorrectly or inappropriately, inbuilt interlocks cannot be relied upon to detect failure states. For this reason, failures related to calibration were generally given a severity score of 10. Where there were known drifts, the severity was based on the upper threshold expected within the lifetime of that component. For example, over the lifetime of a typical monitor chamber, output was known to drift by

"ANNUAL QC WAS SIGNIFICANTLY REDUCED AND FOCUSED ON PERFORMANCE CHECKS, WHILST PATIENT SAFETY CHECKS ARE PERFORMED AT HIGHER FREQUENCIES

10–15%, therefore a severity score of 10 was assigned. However, a severity score of 3 was used for a drift, or error in calibration of, kV blade position as at worst a patient would require additional imaging or receive a relatively minor increase in dose from verification.

Some failures were harder to score than others, an example being collision interlocks. At first, we considered the failure to be a collision with a patient, couch or accessory, so we set a detectability score of 1, as a significant collision would be immediately identified. With a potentially high severity, but relatively few occurrences, the resultant RPN was below 40 so additional QC would not have been required. This definitely did not feel right. However, if we consider the failure mode to be a collision interlock not triggering, the severity would be the same, but the failure mode would not be detectable in general use. This seemed more reasonable, so QC was needed to reduce the risk.

If we were not confident in how a system could fail, we took a cautious approach and scored it high. An example of this is with the respiratory gating system. We didn't think it would be likely (occurrence 2) but if there was a desynchronisation between gating window and beam on, there could be a complete geometric miss (severity 10) that would be difficult to detect (7), resulting in an RPN of 140. To reduce this to an acceptable risk we added in a daily test to confirm function and a more thorough monthly test (enhanced QC) which measured change in lag time. Previously this test was only done on an annual basis, which is not appropriate if you are looking for a sudden failure.

Compare the results

Once we had compiled a list of QC checks based on risk analysis we compared the results with our current protocol. This highlighted some failure modes that we had not accounted for (failure of imagination), so we added them in. We also included some tests as a performance check of the system. These were introduced to pick up failures before they became a risk to the service. For example, the older style of monitor chambers (which some of our machines still have) may start to exhibit signs of fast asymmetry prior to failure. Although there is no significant dosimetric impact on a patient, it is something that we can detect early, approximately a year before the chamber fails. A check mitigates the risk of sudden complete failure and, hence, a reduced impact to the clinical service.

The justification for all deviations from our previous protocol were very clearly documented. One result from this work was that our annual QC was significantly reduced and focused on performance checks rather than patient safety, which are performed at higher frequencies. In total we have estimated that there will be a 30% reduction in required QC time over a year.

We were in a fortunate position to have a new experienced medical physics expert join our department towards the end of this project. They independently reviewed all our failure modes, scoring and resultant QC prior to introducing it. This gave us confidence that the changes were reasonable. Because of this work, we have an optimised and more relevant QC schedule. We are in the process of repeating this work for our other treatment machines, such as Halcyon.

Table 1 Risk prioritisation number = severity x occurrence x detectability

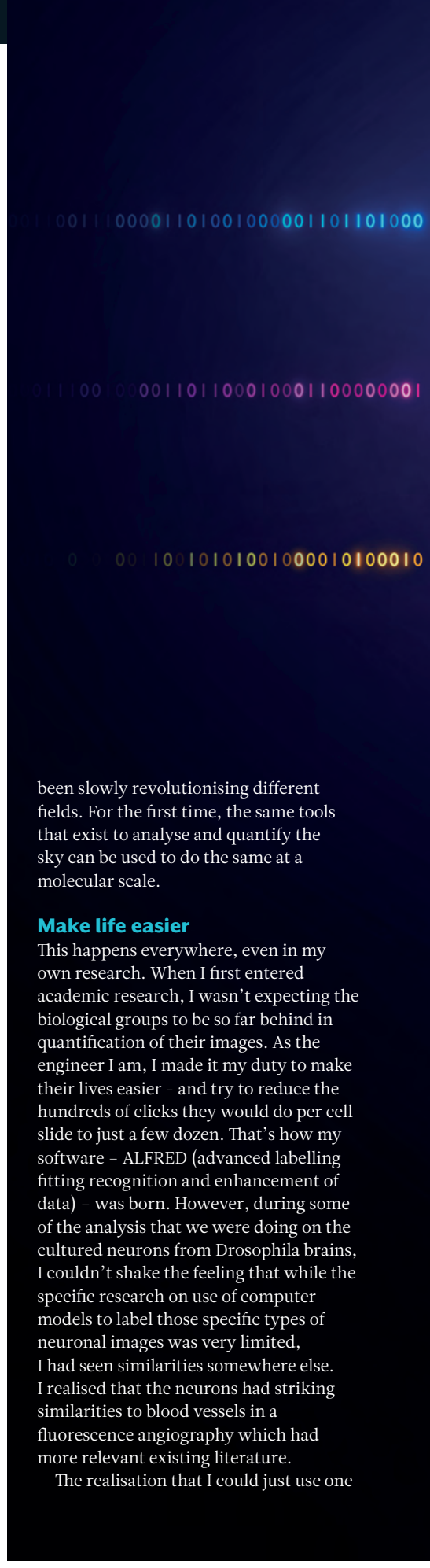
Failure mode	Beam MU calibration variation	Incorrect beam initiation or termination time
Process	Beam production	Respiratory gating
Potential cause(s)	Drift in monitor chamber sensitivity	Faulty cabling, processing, latency
Severity (S) No QC	[2]10	[5]10
Occurrence (O) No QC	[2]2	[6]2
Detectability (D) No QC	[3]10	[7]7
RPN (S x O x D) No QC	200	140
QC action	Daily output constancy Monthly reference output measurement (enhanced QC)	Daily visual check of beam on/off Monthly measure of latency (enhanced QC)
Severity (S) With QC	10	10
Occurrence (O) With QC	2	2
Detectability (D) With QC	[4]2	[8]2
RPN (S x O x D) With QC	40	40

[1] This score is based on local QC results. Typical drift of a monitor chamber can be 10–15% over its lifetime. This would result in a significant dosimetric error.
[2] The typical drift of a monitor chamber is well known. It takes significant time for a drift of 10–15% to occur. No sudden changes have occurred locally.
[3] If no QC was completed we would not detect a change of this magnitude.
[4] A daily check of output increases the likelihood of detecting a change in output. On this occasion, QC does not change the severity or the occurrence of the failure.
[5] There could be an undefined geometric error for a gated plan meaning no therapeutic dose delivered to tumour or significant overdose to an organ at risk.
[6] There is no previously known occurrence of this failure. Unsure whether it can happen at all. Additionally, there is no real-time anti-virus scanning to prevent delays.
[7] As there is an audible signal when the beam is on, you may notice that the beam is not synced to the gating system.
[8] A basic daily check to ensure that the beam is appropriately synced improves detectability. A monthly test is added to measure the latency compared to baseline.

Katherine Sutton, ***Kevin Brownsword*** *and* ***Adam Fryer*** *are from Hull University Teaching Hospitals NHS Trust.*

COMPUTER SCIENCE VS BIOLOGY

Research Fellow **Dr Beatriz Costa Gomes** looks at the positive impact of AI in medical research and how to best harness that power.



While the first scientists were jacks of all trades, science evolved to traditionally be divided into boxes that didn't often overlap. As a result, when I was growing up, I thought it was a world of an "either/or" paradigm – I could be a wet lab scientist immersed in biology or medicine, or pursue a career as a computer scientist. This doubt haunted my formative years, as I couldn't make the impossible decision of which of my passions was the one I loved the most. It was only much later that I realised the power that lives within the "and".

More than anything, computer science has become the overarching bridge between the fields. In an era of technological advancement, there are very few fields that don't benefit from the computational boom. Whether it is used for something as complicated as programming the exact location where a rover will land in Mars, or a simple use of a sophisticated language model to proof-read an article. In a way, it's as if we're back to the time where for someone to be a mathematician they had to be a philosopher too. Only now, everyone needs a little bit of a computer scientist inside them, as grim as that sounds!

The power of AI

Artificial intelligence exemplifies this interdisciplinary convergence: it's a great tool to actually enhance discoveries in other fields, if only due to the sheer amount of data that can now be processed.

Only a few decades ago, biologists would have to sit in the dark for hours while manually outlining the relevant part of their fluorescence images. Now, with a few clicks and the use of segmentation methods already implemented in the software of their pipelines, they can use those hours to actually prepare and conduct new experiments.

But it is also more than that, it's allowing us to discover things that we wouldn't be able to otherwise. The power of the predictive models and how they can see patterns in the data has been slowly revolutionising different fields. For the first time, the same tools that exist to analyse and quantify the sky can be used to do the same at a molecular scale.

Make life easier

This happens everywhere, even in my own research. When I first entered academic research, I wasn't expecting the biological groups to be so far behind in quantification of their images. As the engineer I am, I made it my duty to make their lives easier - and try to reduce the hundreds of clicks they would do per cell slide to just a few dozen. That's how my software – ALFRED (advanced labelling fitting recognition and enhancement of data) – was born. However, during some of the analysis that we were doing on the cultured neurons from Drosophila brains, I couldn't shake the feeling that while the specific research on use of computer models to label those specific types of neuronal images was very limited, I had seen similarities somewhere else. I realised that the neurons had striking similarities to blood vessels in a fluorescence angiography which had more relevant existing literature.

The realisation that I could just use one

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type of analysis done in one scale to apply to another had a higher impact than I anticipated. It was also striking that most of the times that I presented my work, I was asked if my neuronal-software would work for anything else in other types of images. My answer was always the same: the camera that was used to take the photo doesn't matter, we're all just looking at blobs.

Collaboration

By building these bridges and crossing fields, fostering collaborations and interdisciplinary exchanges, we can actually avoid the reinvention of the wheel every time we come across a challenge, and use the collective knowledge from the different fields to overcome the common enemy. We can bring the fields to the same decade, without having to wait centuries! While I am prone and a fan of exaggerations, in this case I'm afraid it is literal, and we only need to look at how long it took for integrals to be used in medicine (and how papers from the last century have hundreds of citations!).

A part of the work that I do currently is exactly that: making platforms that handle the data and make it ready so anyone can try using machine learning models on their data, regardless of the origin. This proactive approach aligns with my goal of making computational tools accessible for researchers across diverse domains.

Additionally, the truth is that we couldn't get the models that we do now if we didn't have the scientific and technological advances. The sheer processing power needed for these models required advanced engineering solutions, the data had to be collected, cleaned and formatted, which then allowed for the models to be trained and run, which allowed the theory to be further developed. It's a perpetual machine of knowledge where it feeds itself and creates more knowledge.

> **"WE CAN BRING THE FIELDS TO THE SAME DECADE, WITHOUT HAVING TO WAIT CENTURIES**

Will AI take our jobs?

Given how advanced the models are, and how popularised AI has become, I often get asked if it is worth doing research, or if AI will take all our jobs. Firstly, if the models were as advanced as we are made to believe, my job would be much easier – so, unfortunately, that isn't the correct picture. Secondly, there's so many things we still don't know or understand, and there's so much space to advance science, regardless of the tools that we end up using. What I think is important - and more prominent in the future of science - is that we learn how to communicate between different "languages". There is a lot of power in using neural networks to analyse neural networks and understand that sentence. And regardless of how you understood it, it's still valid.

So, the choice presented to my younger self was not on whether I would do medical research or use computers, but rather what parts of computer science did I want to use in medical research?

Dr Beatriz Costa Gomes *is a Research Fellow in AI in health*

FROM CLINICAL SCIENTIST TO HEALTH DATA SCIENTIST

Helen Chamberlain, Scientific Advisor in Data Access and Analytics, looks at the benefits of pursuing a varied career.

I was never someone who knew exactly what they wanted to do when they grew up – I was interested in everything. Even settling on my choices for GCSE was hard, let alone only being able to choose just a handful of subjects for A-Level, a degree and then a career to work in for at least four decades. Luckily for me, following a brief introduction to medical physics at A-level and a week of work experience, I found myself setting out on a career as a clinical scientist in radiotherapy physics. And I loved it.

One thing that I had always particularly enjoyed was research, especially projects that involved analysis of large, complex datasets. For example, the MSc project I completed during the STP programme involved analysing a decade's worth of outcomes data for those treated with brachytherapy for cervical cancer. I enjoyed the fact that data analysis could provide robust evidence of how to make things better for lots of people. And data is important: at a recent conference presentation from economist and broadcaster Sir Andrew Dilnot, he made the case that data should be seen as central to our understanding of the world and decision making, not simply seen as a way of evidencing things we already believe.

Data in the charity sector

When I saw a job as a Health Data Insight Analyst advertised at Macmillan Cancer Support, I was intrigued. Despite a long history volunteering for a range of charities, I hadn't realised that they would have teams of people working as data scientists and analysts. Macmillan was close to my heart due to working in cancer care and because of the support provided to relatives who had been diagnosed with cancer. Once I started in the role it made a lot of sense why healthcare charities needed not only data analysts, responsible for maintaining the "business" functions of the charity, but specialist health data analysts.

Charities such as Macmillan perform a wide variety of functions, although they are probably best known for their direct provision of services, which includes directly employing health professionals that work in the NHS and offering free support via their helpline, website and support centres. They are also involved in a lot of advocacy and policy work, ensuring that the needs of people living with cancer and the professionals and carers that support them remain close to the top of the political and social agenda. Possibly less well known is the fact they do their own research, contributing to the wide body of evidence of what we all know about cancer and cancer care.

All these functions require data, to understand the population of people living

with cancer and the health systems they interact with. It also requires a highly specialised skill set, needing advanced analytical skills to tackle very complex data sources, a well-developed understanding of people, diseases and health systems and great data communication skills. As an analyst you must also have the ability to quickly adapt to new data sources and different ways of disseminating information – you might be working on a piece for academic publication at the same time as a national media campaign, as well as maintaining the day-to-day analysis that informs how the charity operates.

Examining health inequalities

A key project I led on examined how the concerns voiced by people living with cancer, and the subsequent support offered to them, varied depending on factors such as personal characteristics, type of cancer and what stage of the cancer pathway they were in. This used data from Macmillan's electronic Holistic Needs Assessment platform, used by NHS trusts across the UK, which enables creation of a personalised support plan for those living with cancer. The dataset is large (around 100,000 new records are set up every year) and very complex, but is an incredibly valuable resource to examine what unmet or under-met needs different groups of people living with cancer have.

What is fantastic about this dataset is not only does it contain data on individual's needs and symptoms surrounding cancer diagnosis and treatment, but also contains data about their wider needs. This includes their emotional and practical needs, such as concerns around how to tell loved ones about a cancer diagnosis, or difficulties with money and finance. This data is usually not captured, at least at this scale. Analysis of datasets like this are crucial to ensure the entire system required to support those facing life changing diagnoses meets the needs of everyone who needs it. This is particularly important as we try to tackle health inequalities, which in turn should improve both cancer outcomes and experience for everyone. And we need lots of different perspectives involved in the conversation about that change – from those living with cancer, to health professionals, policy makers – and people who can bridge the gap between these perspectives.

Broadening my perspective

As such, I actually see my pivot from clinical scientist to data scientist as less a career change, and more taking an opportunity to use my skills in a different way. Healthcare scientists have lots of specialist skills and domain-specific knowledge, but they also have a wealth of transferable skills – although it can be hard to translate your experience for people who have never even heard of healthcare scientists. My background has absolutely been crucial in giving me the skills I need, but I also bring experience that has proved useful beyond my immediate day-to-day role. My knowledge of radiotherapy and the realities of cancer pathways and health systems has meant I've been able to contribute to a wide range of tasks, beyond that of someone who has only worked in data analysis. After all, context is everything and communicating about data requires an understanding of the underlying story.

In turn, I've also learnt a lot. Not only advancing my knowledge of health statistics, epidemiology and the wider cancer care system, but also challenging my ways of working and thinking about the world. I've been involved in developing Macmillan's new strategy, which has required much more expansive and creative thinking - we need to work out how to support the growing population who need care, who have increasingly complex needs. I have also really developed my understanding of what good cancer care currently looks like, and what the consensus is on what it should look like.

The cancer care system is incredibly complex, and many different people and sectors play a role. We need people delivering excellent front line care, both patient facing and behind the scenes, but we also need academics and people in industry who can help push the boundaries of what is possible. Finally, charities and other arm's-length organisations provide incredibly useful services – they have the capacity and resources to understand the world from local, national and international perspectives, and the ability to influence at the highest levels.

In the last month I've actually transitioned to a new role, working as a Scientific Advisor in Data Access and Analytics at the National Institute for Health and Care Excellence (NICE). It's fascinating seeing the health system from yet another perspective. For me, working in different organisations, in different sectors and with different people has hugely improved my skills. I think clinical scientists can bring a lot to many different organisations, who often have few people working for them from a clinical background, particularly with experience of science and technology in health. But equally, if I return to clinical science in the future I'd undoubtedly return enriched, with a fresh perspective.

I opened this article by discussing how hard I found it to whittle down my options. I now think that maybe we shouldn't be so keen to stop pursuing our different interests in order to focus on a singular goal – for me doing something different, at least for a while, has offered me great development opportunities, and the chance to really expand my horizons.

In turn, I think that the healthcare, charity, academic and other sectors are improved by being open to people from a wide range of backgrounds. It's not hard to find common ground, but by encouraging people to learn new things and appreciate different perspectives we'll only strengthen what we can provide for people who require support from health and care services.

Helen Chamberlain *is a Scientific Advisor in Data Access and Analytics at the National Institute for Health and Care Excellence*

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IPEM is delighted to partner with The Royal College of Radiologists (RCR) for their inaugural Global AI Conference 2025, *Shaping the future of AI in healthcare*.

In partnership with the NHS, this landmark conference unites over 20 UK and international organisations to drive the AI revolution in healthcare. Join us on 3-4 February 2025 at The Queen Elizabeth II Conference Centre in London or participate online, as we empower clinicians to harness the potential of AI across a wide range of clinical specialties.

The future of AI

The conference will showcase the future of AI through inspiring talks and presentations by UK and global leaders with a selection of high-level panel discussions involving industry leaders, politicians and decision makers.

Dr Anna Barnes, President of the IPEM, has supported the AI Committee in shaping the conference programme.

She said: "AI-designed technologies will be increasingly present in healthcare; from software to connected devices to workflows and procedures. The ownership, responsibility, regulation and continued safety and quality monitoring of these systems represent interesting questions that will require cross-functional discussions.

"We must ensure AI is deployed in the interests of patients and led by healthcare professionals, with AI-specific standards to ensure safe, effective development and clinical use, and invest to improve digital skills. This conference is especially timely, therefore, and as the professional body for medical physicists, clinical engineers and clinical technologists, professions that will be at the forefront of the AI revolution, IPEM is delighted to be a partner".

Join us in-person or online for an immersive experience packed with thought-provoking discussions, inspiring keynotes from industry leaders, interactive workshops and dynamic panel discussions. In total, 16 CPD credits are available across the two days with further opportunities to earn over 50 additional credits by viewing online recordings and self-certifying post conference. Secure your spot now and benefit from early bird rates.

Explore and register

Explore the online programme and register today at **bit.ly/IPEMAIConference**. Look out for further announcements in September!

IPEM members are also invited to showcase their groundbreaking AI projects and research in the abstract competition by submitting their work no later than Monday 16 September, 23:59 (BST). Share your innovative approaches to enhancing patient care, pathways and improving services.

Elevate your profile by having your work published in the new open-access journal, *RCR Open*, featured as a poster in the exhibition and included on the conference app.

The winners and runners-up will be announced by Dr Katherine Halliday, RCR President and Professor Owen Arthurs, AI Conference Committee Chair.

THE CONFERENCE WILL SHOWCASE THE FUTURE OF AI THROUGH INSPIRING TALKS AND PRESENTATIONS

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ESTRO SHINES IN GLASGOW

Paul Doolan reports from the European Society for Radiotherapy and Oncology (ESTRO) conference, held in May.

It wasn't the thousands of fans that descended on Glasgow to see Take That that were asking "*Could It Be Magic?*", but the 7000+ attendees in an adjacent building for the ESTRO conference that had the *Greatest Day*. On 3–7 May, nearly 3000 abstracts were presented across 210 sessions by 325 invited speakers. Topics were wide ranging and spanned all areas of radiation therapy, from brachytherapy to adaptive therapy, from clinical outcomes to predictive diagnosis, from AI to reirradiation – everything you need to *Shine* in radiation therapy. Understaffed clinicians, overworked scientists and under-funded researchers all came together to *Relight My Fire* and become re-energised with the novel work being conducted in our field.

Exhibition

A total of 97 exhibitors tried to entice attendees to their stands, but it was Elekta who stole the show with the unveiling of their new Linac, Evo. It represents a major step for Linac manufacturers, offering X-ray-based online adaptive therapy for the first time following an overhaul of their cone beam computed tomography imaging reconstruction algorithm. Major rivals Varian have offered online adaptive therapy through their Ethos system since 2019, but this machine, together with the adaptation platform inspired by Elekta Unity, promises that *It Only Takes a Minute* – actually 20 minutes is the promise from Elekta – to adapt the plan to the patient's anatomy of the day. The advantage? Patients only need adaptation when *Everything Changes*.

Artificial Intelligence (AI)

AI and its application featured heavily in the scientific sessions, as it is set to *Rule the World*. A highlight was "AI in Daily Practice", with perspectives from different staff groups. Providing the view from physics, Cornelius van den Berg from Utrecht presented their system to monitor the agreement between the clinically-accepted structures and the AI contours. With this system they were able to understand how much editing is required and could spot when their practice had changed – for example, a particular MRI sequence had changed within their clinic and more editing was being performed. These sort of monitoring programmes are necessary and will become commonplace as AI embeds into the clinic. The oncologist, Jesper Grau Eriksen from Aarhus, provided startling statistics to show how AI can help in our struggling field. AI offers the opportunity to lighten the workload for specific, well-defined, tasks. It also significantly improves consistency, with the Danish Head and Neck Cancer group (DAHANCA) trial cited as showing that heterogeneity reduces when AI was used as the starting position.

Sophie Perryck from Zurich presented the view from the radiotherapist, with a series of thoughtful suggestions to integrate AI into treatment. Instead of automatic matches based on geometry, a consideration of previous matches could be considered to see where there is the greatest uncertainty. AI could give an indication of when plan adaptation is required. And instead of using a hospital tolerance for shifting, it would be desirable to have a different tolerance for each patient, considering their particular histology or staging.

National Societies evening

After the completion of the scientific sessions, more than 100 registrants remained to attend the National Societies evening, where presentations were given on European-wide projects such as the Value Based HealthCare for Radiation Oncology project and the efforts of UEMS and EFOMP and to harmonise radiation oncology and medical physicist training, respectively.

Fruitful discussions were held both during and between sessions. Seeing the perspectives of different countries, both large and small, is vital as ESTRO works to harmonize and improve care quality across Europe.

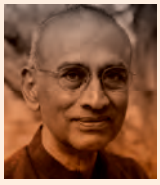
Best coffee

The now-annual competition for the best coffee was won by Boston Scientific. Attendees voted with their feet, judging by the size of the queues at each break between sessions. In Vienna in 2023, ice creams were offered to try and entice attendees to one stand, but the most innovative offering this year was from GE, who offered drinkers the chance to print their own face on a latte. The number of delegates will surely be on the rise again next year as we *Pray* and wait to see what surprises the GPT Food Stand will serve up – perhaps a cappuccino that finally knows *How Deep Is Your Love*.

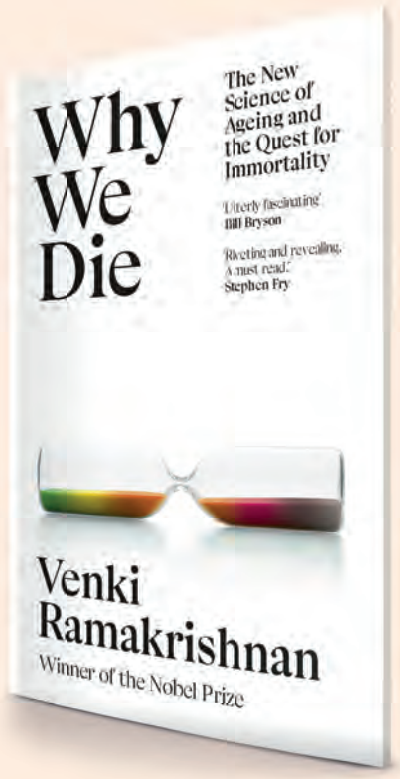
Paul Doolan *is the General Co-ordinator of Medical Physics, Department of Medical Physics, German Oncology Centre, Limassol, Cyprus*

BOOK PITCH

Why We Die:
The New Science of Ageing and the Quest for Immortality



Nobel Prize winner **Venki Ramakrishnan** outlines the idea behind and the content within his new book.



For centuries, our life expectancy hardly changed. But over the last 150 years, we have doubled it, primarily because we better understood the causes of disease and its spread, and improved public health. But extending maximum life span – the longest we can expect to live even in the best of circumstances – is a much tougher problem. Is our life span fixed, or could we slow down or even abolish ageing? And could we learn anything from other species, whose lifespans vary from days or weeks to hundreds of years?

Much of the world is faced with a growing elderly population, and keeping them healthy for as long as possible has become an urgent social imperative. This has resulted in an explosion in ageing research. In the last ten years alone, more than 300,000 scientific articles on aging have been published. More than 700 start-up companies have invested a combined many tens of billions of pounds to tackle ageing – and this is not counting large, established pharmaceutical companies that have programmes of their own.

This enormous effort raises a number of questions. Could we eventually cheat disease and death and live for a very long time, possibly many times our current life span? Certainly some scientists make that claim. And California billionaires, who love their lifestyles and don't want the party to end, are only too willing to fund them.

Given recent advances and the enormous amount of money pouring into ageing research, we must ask where this research is leading us, as well as what it suggests about the limits of human beings.

> **"MY BOOK IS SOMETHING OF A ROMP THROUGH A LOT OF MODERN MOLECULAR BIOLOGY**

I have spent most of my long career studying the problem of how proteins are made in the cells that make up our body. The problem is so central that it impinges on virtually every aspect of biology, and over the last few decades, we have discovered that much of ageing has to do with how our body regulates the production and destruction of proteins. But when I started my career, I had no idea that anything I did would be connected with the problem of why we age and die.

Although fascinated by the very real breakthroughs in our understanding of ageing, I have also watched with growing alarm the enormous amount of hype associated with it, which has led to widespread marketing of dubious remedies that have a highly tenuous connection with the actual science.

Because aging is connected intimately with so many biological processes, my book is something of a romp through a lot of modern molecular biology. It will take us on a journey through the major advances that have led to our current understanding of why we age and die. We will explore the programme of life governed by our genes, and how it is disrupted as we age. We will take a dispassionate look at the most recent efforts being made to extend life span and whether they live up to their hype. I hope to probe, as well, the crucial ethical question that runs beneath anti-ageing research: Even if we can, should we? ○

Why We Die: The New Science of Ageing and the Quest for Immortality *is published by Hodder Press (hardback £25).*

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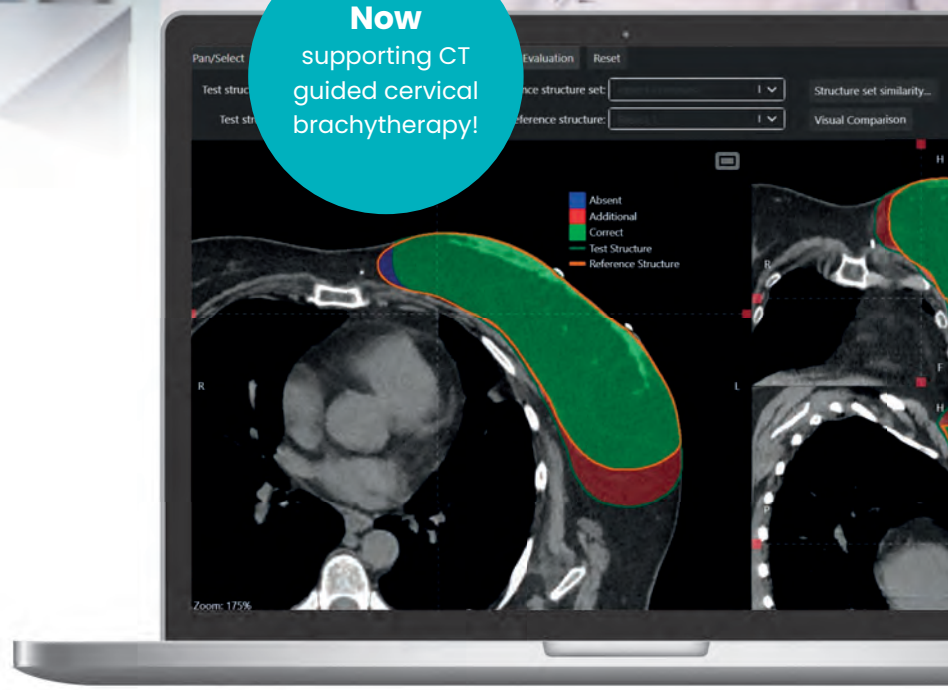

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