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Volume 36 | Issue 02 | Summer 2025

IPEM
Institute of Physics and Engineering in Medicine

SCOPE

FROM SCANS TO SOLUTIONS

How artificial intelligence is revolutionising brain health

ACADEMIC TO INDUSTRY

An industrial scientist on his motivation to start a company

ULTRASOUND

A project on ultrasound elastography quality assurance

SOCIAL MOBILITY

The barriers that prevent young people engaging in science

3D PRINTING

The need for guidance on compliance and risk assessment

CHAIR OF IPEM SCOPE EDITORIAL ADVISORY BOARD

Positive change for patients

Usman Lula outlines the content in the latest issue, including AI and brain disorders, 3D printing in radiotherapy and ultrasound elastography.

Welcome to the Summer issue of *Scope*! We're excited to bring you the latest articles from the vibrant, ever-evolving world of medical physics and engineering. Firstly, a heartfelt thank you to all our contributors and the *Scope* commissioning board – your dedication and insights make each issue possible.

Our cover story, "From Scans to Solutions", beautifully captures the spirit of our profession and the mission of IPEM: turning scientific discovery and technical innovation into positive change for patients. At the heart of this issue is a deep-dive into one of the most transformative frontiers in healthcare – artificial intelligence (AI) in brain health.

Our lead feature, authored by *Scope* commissioning board member Dr Moses Sokunbi, provides a compelling look at how AI is revolutionising the diagnosis and treatment of brain disorders. It demonstrates how AI enables more accurate, timely and personalised care by enhancing our ability to interpret complex imaging data and spot subtle patterns that might otherwise go unnoticed.

We're grateful to Luke Eason for his contribution exploring the growing use of 3D printing in radiotherapy. His piece showcases a fascinating workshop where speakers demonstrated how 3D printing is becoming more accessible.

But progress in our fields isn't just about machines and data – it's also about the patients we serve, the communities we engage with, and the care with which we conduct our work. In her article on ultrasound elastography, Virginia Marin Anaya shares feedback from public engagement events around breast screening. Her piece underscores how listening to patient voices, acknowledging anxieties, and responding to diverse needs can make screening more effective and compassionate. Likewise, in a moving letter, Terry Hawkin invites us to reflect on the ethical challenges and shares a personal perspective on moral injury in nuclear medicine.

> Progress in our fields isn't just about machines and data – it's also about people.

We're delighted to feature an inspiring contribution from Gill Collinson, the new CEO of IPEM, who shares her vision for enhancing the recognition and visibility of our professional body. Her words reflect a real energy and commitment to shaping the future of our field.

Alongside this, we bring you highlights from a highly successful Healthcare Science event at Westminster, as well as a thought-provoking update on the current state of our profession, informed by a recent survey.

Usman Lula

Usman Lula
Chair of IPEM Scope EAB

VARIED JOURNEYS

A shared commitment to making a difference

We're proud to launch a new series, "Shape the Future: British Standards Institute," where Stephen Rae introduces the critical role that standards play in ensuring safety and quality across medical devices. It's also a call to action, showing how we can help shape the future of healthcare.

This issue also celebrates the varied journeys people take through our profession. Dr Mark Gooding offers a personal account of his transition from academia to industry, candidly sharing the motivations and lessons learned in founding a company driven by the goal of improving patient care. In "Reflecting on a Journey," my colleague Sagar Sabharwal describes the rewarding experience of publishing his first article, focused on optimising radiation dose in radiotherapy. Stories like these remind us that, whether we're working in research, industry, or the clinic, we're all united by a shared commitment: making a difference for patients.

IPEM
Institute of Physics and Engineering in Medicine

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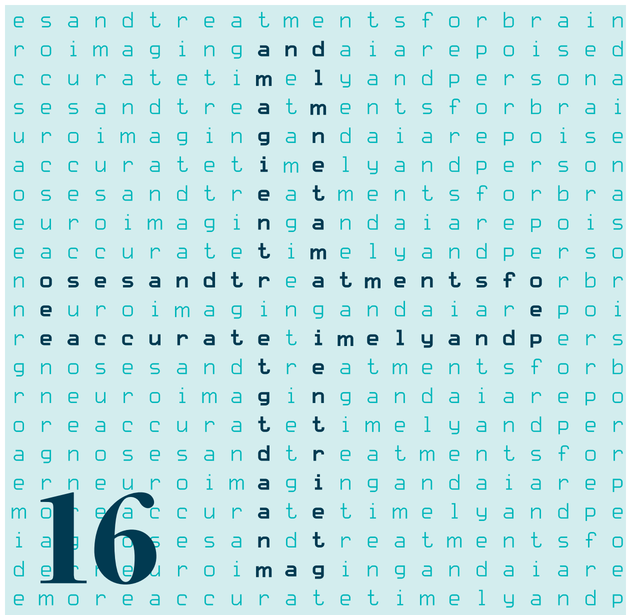
COVER FEATURE



In this issue's cover feature, we explore the groundbreaking techniques in neuroimaging, delve into the role of artificial intelligence in processing and interpreting brain scans and go on to examine how the fusion of these technologies is driving innovative solutions in diagnosing and treating brain disorders.

> The future holds immense promise for brain health, offering new opportunities for diagnosis, treatment and enhancement that were once unimaginable.

Dr Moses Sokunbi
Senior Lecturer at the Faculty of Health and Life Sciences, De Montfort University **page 16**

UPFRONT

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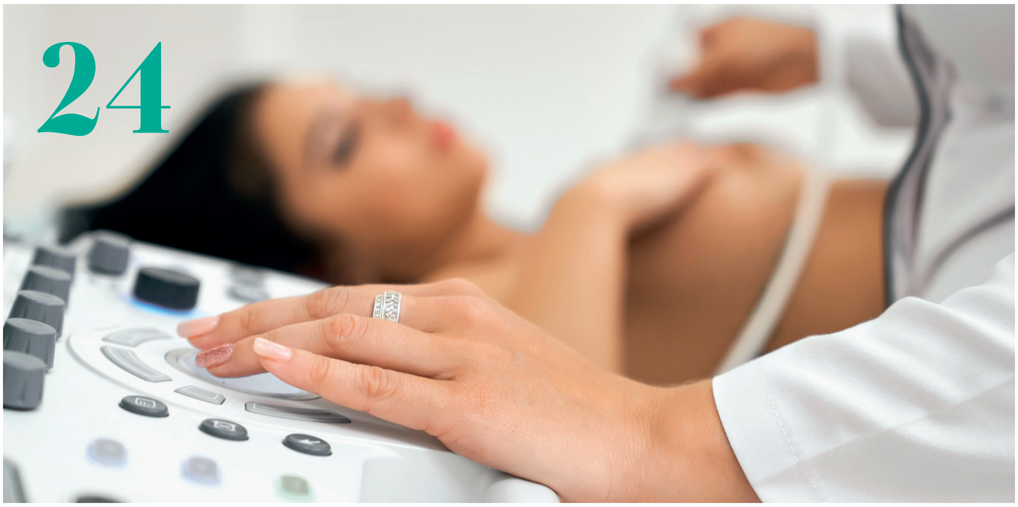

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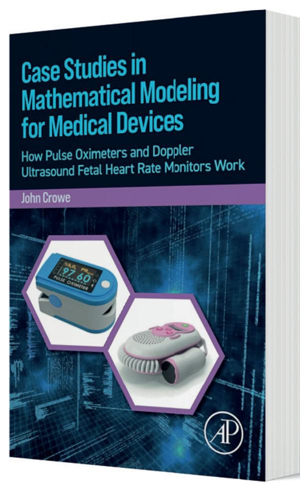
ENDNOTES



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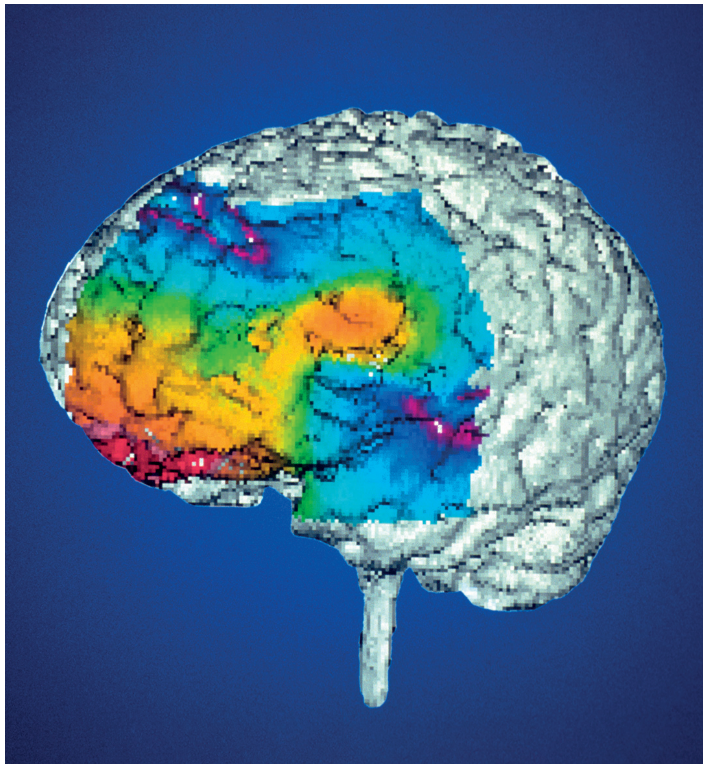
UPFRONT



MAGNETIC RESONANCE IMAGING

Powerful MRI scans for epilepsy

A new technique has enabled ultra-powerful magnetic resonance imaging (MRI) scanners to identify tiny differences in patients' brains that cause treatment-resistant epilepsy.

In the first study to use this approach, it has allowed doctors at Addenbrooke's Hospital in Cambridge, to offer the patients surgery to cure their condition.

Previously, 7T MRI scanners – so called because they operate using a 7 Tesla magnetic field, more than double the strength of previous 3T scanners – have suffered from signal blackspots in crucial parts of the brain. But researchers in Cambridge and Paris have used a technique that overcomes this problem.

Around 360,000 people in the UK have a condition known as focal epilepsy, which causes seizures to spread from part of the brain. A third of these individuals have persistent seizures despite medication, and the only treatment that can cure their condition is surgery. Epileptic seizures are the sixth most common reason for hospital admission.

In order for surgeons to perform this operation, they need to be able to see the lesions (diseased tissue) in the brain responsible for the seizures. Then, they can work out exactly which areas to remove to cure the patient's epilepsy. If surgeons are able to see the lesions on MRI scans, this can double the chances of the patient being free of seizures following surgery.

Ultra-high field 7T MRI scanners allow much more detailed resolution on brain scans and have been shown in other countries to be better than the NHS' best 3T MRI scanners at detecting these lesions in patients with drug-resistant epilepsy (and most NHS hospitals have even weaker, 1.5T scanners). However, 7T MRI scans are susceptible to dark patches known as signal dropouts. These dropouts commonly occur in the temporal lobes, where most cases of epilepsy arise.

To overcome this problem, researchers at the University of Cambridge's Wolfson Brain Imaging Centre, working with colleagues at the Université Paris-Saclay, trialled a technique known as "parallel transmit", which uses eight transmitters around the brain rather than just one to avoid the problematic drop-outs.

Chris Rodgers, Professor of Biomedical Imaging at the University of Cambridge, said: "By using multiple radio transmitters positioned around the patients' head – like having a wifi mesh around your home – we can get much clearer images with fewer blackspots. This is important for the epilepsy scans because we need to see very precisely which part of the brain is misbehaving."

b.link/wxyi1kg5

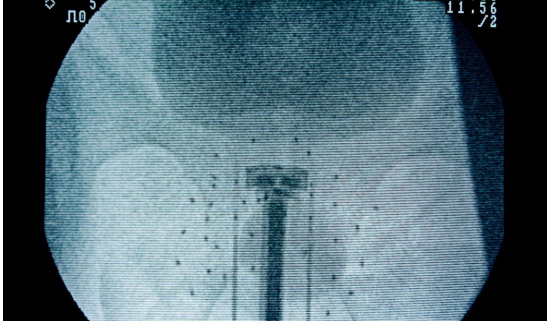
IMAGE: SCIENCE PHOT LIBRARY

FAST FACTS

X2
7T MRI SCANNERS
These scanners are more than double the strength of previous 3T scanners.

360,000
The rough number of people in the UK who have focal epilepsy.

31
The team tested their approach with 31 drug-resistant epilepsy patients.



PROSTATE CANCER

Safety and efficacy of higher-dose-per-day radiation

A new large-scale study provides the strongest evidence yet that a shorter, standard-dose course of radiation treatment is just as effective as conventional radiotherapy for prostate cancer, without compromising the safety of patients.

The shorter approach, known as isodose moderately hypofractionated radiotherapy (MHFRT), delivers slightly higher doses of radiation per session, allowing the total treatment duration to be over four to five weeks instead of seven to eight weeks.

According to the study, patients who received isodose MHFRT had the same cancer control rates as those who received conventional radiotherapy. Additionally, the risk of long-term side effects affecting the bladder and intestines was no higher with MHFRT, confirming its safety.

Dr Amar Kishan, co-first author of the study, said "We believe these data strongly support that isodose MHFRT should become the preferred standard of care MHFRT regimen for prostate cancer."

Kishan and the team of researchers examined data from a total of more than 5800 patients across seven randomised clinical trials comparing standard therapy with two different MHFRT approaches: isodose MHFRT, a technique that maintains the total radiation dose at a level similar to standard therapy, and dose-escalated MHFRT, which increases the total dose in hopes of enhancing tumour control.

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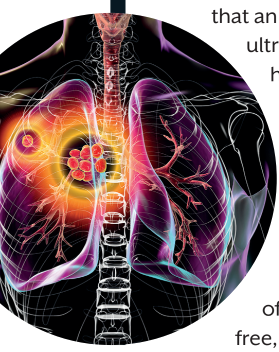
PULMONARY TUBERCULOSIS

AI-GUIDED LUNG ULTRASOUND FOR TB



A new study has demonstrated that an AI-powered lung ultrasound outperforms human experts by 9% in diagnosing pulmonary tuberculosis (TB).

The ULTR-AI suite analyses images from portable, smartphone-connected ultrasound devices, offering a sputum-free, rapid and scalable alternative for TB detection. The results exceed the World Health Organization (WHO) benchmarks for pulmonary tuberculosis diagnosis, marking a major opportunity for accessible and efficient TB triage.

Lead study author Dr Véronique Suttels said: "The ULTR-AI suite leverages deep learning algorithms to interpret lung ultrasound in real time, making the tool more accessible for TB triage, especially for minimally trained healthcare workers in rural areas. By reducing operator dependency and standardising the test, this technology can help diagnose patients faster and more efficiently."

b.link/b4b5wojf

NEWS IN BRIEF

Citrus remedy for dry mouth

A natural citrus oil is proving effective in relieving dry mouth – a common side effect of radiotherapy. When combined with a new lipid formulation, research suggests it may be effective without significant side effects. It combines limonene with a lipid-based drug delivery system to treat dry mouth (xerostomia). The new formula demonstrated 180-fold better solubility than pure limonene in lab experiments and boosted relative bioavailability by over 4000% compared to pure limonene in pre-clinical trials.

b.link/s03se5ce

DNA cutting

The advent of CRISPR was a major breakthrough in the scientific world. It enables double strands of nucleotides in deoxyribonucleic acid (DNA) to be cut. This makes it possible to specifically modify a targeted gene in human cells. Professor Frédéric Veyrier at the Institut National de la Recherche Scientifique in Canada and his team have now developed a genetic tool based on a family of specific enzymes called Ssn that allows targeted cuts to be induced exclusively in single-stranded DNA. This breakthrough sheds light on a crucial genetic mechanism that could revolutionise a range of biotechnology applications.

b.link/qok3ajv9

Quantitative PCR

Scientists have developed a tool that may change the way researchers design primers for detecting pathogens. This new pipeline, which scans entire genomes to identify the most effective primer sets, could enhance the speed and accuracy of diagnosing infectious diseases. The findings address a critical challenge in quantitative PCR (qPCR) primer design. This new tool automatically searches across the entire genome, making it easier to develop highly specific and sensitive tests for pathogens.

b.link/cktcs991

CLINICAL RESEARCH

How many cancer cases are due to CT scans?

CT scans may account for 5% of all cancers annually, according to a US study.

The danger is greatest for infants, followed by children and adolescents. But adults also are at risk, since they are the most likely to get scans, the researchers state.

Nearly 103,000 US cancers are predicted to result from the 93 million CTs that were performed in 2023 – three to four times more than previous assessments, the authors said.

"CT can save lives, but its potential harms are often overlooked," said first author Rebecca Smith-Bindman.

The study estimates the total number of lifetime cancers associated with radiation exposure in relation to the number and type of CT scans performed in 2023.

Researchers analysed 93 million exams from 61.5 million patients in the US. The number of scans increased with age, peaking in adults between 60 and 69 years. Children accounted for 4.2% of the scans.

Adults 50 to 59 had the highest number of projected cancers: 10,400 cases to women, 9300 to men.

The most common adult cancers were lung, colon and leukaemia. The most frequent for children were thyroid, lung and breast.

b.link/3pp4h73w

UP CLOSE

EXPOSOMICS

WHAT IS EXPOSOMICS?

A field of study that explores how the complex interplay of environmental factors – from pollutants in our water and food to social and psychological stressors – shapes our biology.

WHAT'S THE LATEST?

This relatively new field is already proving its transformative potential. Researchers analysing molecular evidence identified a specific industrial solvent as the culprit behind kidney disease clusters among factory workers. In another study, scientists merged satellite pollution mapping with residential location information to reveal how airborne particulates prematurely age the brain. Scientists analysing thousands of circulating molecules pinpointed TMAO, a gut microbiome metabolite produced when eating red meat and dairy, as a previously overlooked major contributor to heart attack risk.

HOW WERE THESE MADE POSSIBLE?

Thanks to cutting-edge technologies and tools, such as wearable sensors that track chemical exposures in real-time, satellite imagery that maps pollution down to city blocks, and ultra-sensitive mass spectrometers.

IT SOUNDS PROMISING?

Yes – when combined with genomics, proteomics, and metabolomics, exposomics creates the first complete picture of health determinants. In a new paper authors envision a future where all major disease studies incorporate exposome analysis as standard practice.

WHERE CAN I READ MORE?

b.link/86cb37q5

CANCER RESEARCH

CAN GOLD BE USED AGAINST CANCER?

A French research team has published the first study about the speciation and distribution of an organogold(III) complex in cancer cells and reveal how specially designed "organogold" complexes might open exciting avenues for fighting cancer.

Gold has chemical traits that translate into subtle interactions with biological molecules.

Yet, to date, we have little information about how gold(III) complexes with antitumour activity behave in a biological environment.

The team has now carried out a study using a combination of methods based on synchrotron X-ray radiation – very intensive, bundled flashes of light produced in particle accelerators.

The complexes were demonstrated to be toxic against tumour cells.

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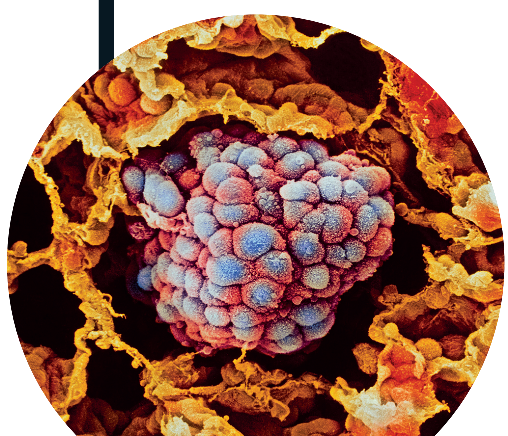


IMAGES: SCIENCE PHOT LIBRARY, ISTOCK

EDUCATION

IPEM PRIZE WINNERS ANNOUNCED

IPEM has sent warm congratulations to the 2024 Masters Level Accreditation Framework (MLAF) prize winners.

The IPEM Student Prize is presented for the best project on an IPEM-accredited MSc course.

The winners each receive £250 and a certificate.

One of the winners was Rhys Jenkins (pictured above) from Swansea University for his project "The Introduction of Three-Dimensional Technologies to a Radiotherapy Physics".

Rhys said: "I am honoured to receive the IPEM prize, and would like to thank my lecturers and supervisors along the way for their encouragement and support."

To see all the winners, visit b.link/q0jdfpdj

NATIONAL CANCER PLAN

"More staff, more local services and more big data" says IPEM

IPEM has submitted evidence to the National Cancer Plan, calling for increased investment in staff, more localised services and better use of big data to improve screening programmes and tackle inequalities.

In its evidence, IPEM said: "It is essential that we address the workforce challenges among diagnostic staff, especially among medical physics and clinical engineering, in order to expand capacity.

"These professionals are essential, for example, in maintaining, calibrating, checking and operating complex imaging equipment to diagnose cancer.

"AI is now enabling the NHS to provide more targeted screening for certain cancers. Genomics, developed by healthcare scientists, has been key to this.

"This technology however, requires a sufficient number of medical physicists and clinical engineers to develop, evaluate and implement new technology safely, effectively and efficiently."

It also called for more localised services. For example, IPEM supports the aspiration for everyone to be within 45 minutes of a radiotherapy centre, saying that the government should "address the huge variation in radiotherapy access across the UK by supporting the safe and robust establishment of new Linac provision in areas currently distant from radiotherapy services".

For more information, visit **b.link/eyyee4dw**

DIARY DATES

VISIT THE B.LINKS FOR DETAILS OF THE INDIVIDUAL EVENTS, OR SCAN THE QR CODE TO VISIT THE "WHAT'S ON" SECTION OF THE IPEM WEBSITE, WHICH HAS DETAILS OF ALL EVENTS AND COURSES

MPE and how to get it
17 June: online
For those looking to become registered and gain certification as Medical Physics Experts through the Assessing body RPA2000.
b.link/zvk3o76a

RPA and how to get it
17 June: online
An overview of RPA, the RPA certification scheme from RPA2000.
b.link/fwaq19lp

South West MPCE Meeting
24–25 June: Bournemouth
The theme is "Progressing and broadening a career in medical physics and clinical engineering".
b.link/jhir5k67

Radiotherapy Biennial
2–3 July: Birmingham
The Biennial Radiotherapy Meeting 2025 is a key event to hear about best practice and innovative solutions to clinical problems in radiotherapy.
b.link/k1r0cnsl

How to write a business case
4 July: online
Aimed at those developing, appraising, or assuring business cases as well as those in leadership roles or aspiring to leadership roles.
b.link/hh4kewxg

Clinical Scientist Guided Training Workshop
7 July: Birmingham
Aimed at clinical scientist trainees who are preparing to submit a portfolio to the Association of Clinical Scientist's Route 2.
b.link/sa39ji2j

HSSE and how to get it
8 Sept: online
Aimed at those looking to become registered as Higher Specialist Scientists through the Academy of Healthcare Science's (AHCS) "equivalence" route.
b.link/19omm5rw

RWA and RPA Updates 2025
9–10 Sept: North East England
IPEM's principal meeting of the year for those working in the field of radiation protection in the healthcare sector.
b.link/em0b47wr

Clinical Risk Foundation Course
25 September: Online
Open to NHS employees, this introductory course covers clinical risk around health IT systems with DCB0129 and DCB0160
b.link/corywjz5

MR Safety Update
15 October: North West England
Join us at this popular biennial meeting where we discuss the latest updates in the ever-evolving subject of MR safety. Abstract deadline 21 July.
b.link/veb5ct3l

IMAGE:SHUTTERSTOCK

PARLIAMENTARY INQUIRY

Call for more apprentices

IPEM has highlighted high average vacancy rates across medical physics and clinical engineering (MPCE), combined with the need to urgently expand the workforce to provide safe, effective, high-quality care.

It did so in evidence submitted to an apprenticeship inquiry being held by the House of Commons Education Select Committee into Further Education and Skills.

In its response, IPEM highlighted the role apprenticeships can play in addressing the MPCE workforce crisis and current barriers to their wider adoption.

It was stressed there are a number of barriers to their uptake – the current lack of places, complex landscape and other factors also act as a disincentive to applicants.

IPEM called for increased investment, promotion and expansion of apprenticeships. It has previously contacted the government to say it is ready and willing to work with them to this end.

For more, visit **b.link/8cv4nswy**

IPEM RESPONSE

ABOLISHING NHS ENGLAND

IPEM understands that the Government's decision to abolish NHS England is a bold step that will cause uncertainty about potential impacts on the medical physics and clinical engineering profession.

It added that IPEM members can be assured that it will be actively advocating for the professions to ensure that workforce issues, are delivered as effectively as possible to address the critical challenges and opportunities facing the MPCE workforce.

As a body representing highly skilled professionals right across the UK, IPEM is also mindful of any knock on effects on services in the devolved administrations and hopes that four nation working can be enhanced.

For more information, visit b.link/vjsr79ur

Following her graduation with a BSc in applied physics, Gill Collinson joined a two-year graduate apprenticeship programme as an electrical engineer at Rolls Royce. "That was a serious learning curve, and I had to pick things up so quickly," she says.

"University gives you the 'why', but in the real world you've got to quickly understand how you do things. Bridging that gap in an environment where you are young and under quite a lot of pressure is a real challenge," she says. "I got there, learned a huge amount about having confidence in my own skills, and it led to an incredible opportunity for me."

That opportunity was a year spent as a commissioning engineer at Sizewell B Power Station, working on the rod control system of the nuclear reactor. An MSc in engineering and computer science, MBA, and roles in engineering and manufacturing at companies including Phillips and Siemens followed.

"I was in industry for more than 15 years and then I moved into business development, working in senior director positions across the public and private sector. My experience has been a

In post since March, CEO **Gill Collinson** has big plans for IPEM to meet the challenges the sector faces, not least the impact of emerging technology.

'THERE ARE SO MANY OPPORTUNITIES FOR MPCE PROFESSIONALS'

blend of engineering, technology and working with people," she says.

When the role of CEO of IPEM came up, it "immediately felt like a perfect fit", she explains. "It was a chance to lead a membership organisation in a profession that I deeply respect. And I don't think it receives the recognition or visibility it deserves. MPCE professionals make up about 1% of the NHS workforce and engage with almost every other part of the service.

Leading on emerging tech

MPCE professionals also engage a "huge amount" with artificial intelligence (AI) and other emerging technologies, using AI to improve clinical outcomes, streamline day-to-day workflows and enhance the overall efficiency of the delivery of healthcare by reducing the administrative burden. It also speeds up research and development and shrinks costs.

The workforce is also "ideally placed" to accelerate data analysis in the healthcare system because it has the critical skills, Gill says. "The profession itself is already making a huge impact in both AI and embedding machine learning into things like radiology and imaging," she says.

These technologies can be used to interpret complex images more quickly and accurately, with reduced anomalies, improve diagnostic precision and alleviate pressure on staff working in imaging services.

Machine learning is also being used to interpret treatment planning systems and optimises dose and distribution, so that treatment plans become more efficient. "There is a huge amount of opportunity with AI and emerging tech," Gill adds. "It's not going to replace the profession but reshape how it operates, impacting the future skills required and approaches adopted."

But the effectiveness of the digital transformation teams established in some NHS trusts is quite inconsistent, and the teams don't always have the technical expertise to deliver the change needed. "Where [those teams] are working well we have the MPCE professionals taking a lead role because they have the technical expertise to implement AI," Gill adds.

She is calling on more NHS trusts to better position MPCE professionals to lead such teams. "MPCE professionals have the domain-specific leadership. They've got the technical skills, and more importantly, can implement those skills into the systems and technologies."

"IT WAS A CHANCE TO LEAD A MEMBERSHIP ORGANISATION IN A PROFESSION THAT I DEEPLY RESPECT

Strengthening the talent pipeline

But the sector still faces workforce shortages. "It's the biggest challenge and that is a growing concern across the NHS, industry and academia. We do have an NHS training pipeline but there's not enough [people] to meet the demand that's needed within the sector" she says.

"What we are seeing in industry is a growing competition for expertise and a growing competition for talent, internationally. That is impacting industry in terms of keeping the development of new medical devices at pace."

"We're seeing declining academic pipelines – fewer people are going to university, fewer people are undertaking PhDs, and that leads to less research and development and a lack of innovation," Gill adds.

The ageing workforce is also a problem. "A third of radiation engineers are going to retire in the next 15 years. That demographic issue is a huge challenge. And it just comes back to the fact that we've not got the pipeline coming through."

So Gill has big plans for the Institute in meeting these challenges and opportunities, not least its role in training and career development, with CPD and training, events and conferences and alternative pathways into the profession, like apprenticeships and industry sponsorships. "It's about showing people that there are multiple pathways into this profession, with opportunities to progress or transition both laterally and upward," she says.

"Linked to that is how we improve retention of professionals already within the sector. For early career professionals, for example, how do we establish structured networking or mentoring opportunities for them? How do we recognise the different roles in the profession and highlight them to people?"

A third key goal for Gill is raising awareness of the profession and strengthening IPEM's influence over policymakers. "We do that through public engagement, whether school engagement, media campaigns, or championing diversity so we are widening access to the profession," she adds.

Grounded in the community

The evolving digital agenda will change the work of the MPCE community. "The profession is going to have to reshape because healthcare is going to become much more personalised, but that also leads to so many opportunities for individuals within this profession."

Her vision for IPEM is to be the leading international organisation representing medical physics and clinical engineering by delivering "unmatched opportunities" for professional development. "That's training and development but also networking and the wider advocacy of the sector, so that we are meeting the needs of the community," she says.

And this sense of a community is key. From her time as a newly-graduated apprentice, Gill remembers the colleagues who were a strong support. "The one thing I'm proud of is the opportunity to mentor and support, particularly people at the early part of their career, seeing them develop their skills and grow with confidence," she says.

"We're grounded in the community we have. They have the expert knowledge. They have the skills, and it's all about collaboration."

IPEM HOSTS MAJOR HEALTHCARE SCIENCE EVENT IN WESTMINSTER

Chris Watt, IPEM Head of Communications and Public Affairs, reports back on an event into the future of the MPCE workforce.

In February, IPEM jointly hosted an event called "Building a Healthcare Science Workforce Equipped to Face the Grand Challenges" in partnership with the Parliamentary and Scientific Committee. The meeting was addressed by Chief Scientific Officer for England Professor Dame Sue Hill, IPEM President Dr Anna Barnes and Chair of IPEM's Clinical Engineering Special Interest Group Dr Victoria Kidgell. It was chaired by former Science Minister George Freeman MP.

Healthcare scientists play a crucial role, not only in healthcare, but in research and development in academia and industry – all sectors represented by IPEM.

With around 200 medical physics and clinical engineering (MPCE) staff at Guy's and St Thomas NHSFT supporting three million patients a year and £300m of equipment, Dr Barnes explained that even a small increase in staff would make a huge difference on the volume and quality of services that can be provided. This workforce challenge is reflected in the NHS and is a key issue that IPEM continues to press policymakers on.

With 10% vacancies, Dr Barnes called for more investment for training at various levels, from apprenticeships to senior scientists.

New technologies need support and integrated care boards should fund the deployment of specific new MPCE posts, to lead on new technologies, including AI tools for diagnosis and treatment, as well as service quality improvement.

Dr Kidgell explained that the grand challenges set out by IPEM in its Science Leadership Strategy include workforce, climate change and clinical safety, whilst the emerging trends are collaboration, smart digitisation, and personalised health.

She explained how clinical engineering developments include advanced diagnostics, personalised treatment, remote monitoring, virtual wards, AI and regenerative medicine.

Sustainability advances have reduced hospital carbon footprints and waste, promoting green healthcare. AI in the NHS can aid diagnosis but a workforce with new digital and data skills is needed to interpret these systems – something IPEM has been raising regularly in its discussions with government and policy makers. The skills gap is a challenge and we need to train the next generation, encourage interdisciplinary collaboration, and embrace new ways of working.

Healthcare scientists can apply scientific and engineering principles, and utilise their research skills putting the patient at the centre of everything. Better recognition could be aided by mandatory professional registration.

Dame Sue explained how healthcare scientists underpin 80% of diagnoses. Current key areas of priority for NHS England include medical imaging, radiation science, medical devices, rehabilitation and patient safety. A highly skilled healthcare science workforce will be more patient-focused, with research opportunities aligned with academia, communities of practice and providing support for clinical entrepreneurs. Dame Sue acknowledged that there is both a need and opportunity for MPCE to be at the centre of developing the health and care agenda of the future.

Those packed into the room had the opportunity for a lively question-and-answer sessions. Topics that came up included the challenges of recruiting new staff, with many speakers arguing that more visibility was needed for all healthcare science professions. There was also a recognition that all recruitment pathways, including apprenticeships, would need to be used to address the workforce challenge. ◘

1 Dr Anna Barnes, IPEM President and Director of the King's College London Technology Evaluation Centre
2 Dr Victoria Kidgell, Lead Healthcare Scientist at Sheffield Teaching Hospitals NHS Foundation Trust and Chair of IPEM's Clinical Engineering Special Interest Group
3 Lord Mair, Parliamentary and Scientific Committee
4 Katherine Bunting, IPEM Director of Education & Professional Development
5 Chris Watt, IPEM Head of Communications and Public Affairs
6 Viscount Stansgate, President, Parliamentary and Scientific Committee
7 Dr Jemimah Eve, IPEM Director of Policy and Impact.

IMAGE: COURTESY OF THE PARLIAMENTARY AND SCIENTIFIC COMMITTEE

STATE OF THE PROFESSION

Survey responses

We must not take historically high levels of staff retention for granted, it is reported after the collation of IPEM survey results.

In late 2024, IPEM carried out its first ever State of the Profession survey for clinical engineering and medical physics. One aim of the survey was to query the opinions of professionals about the inclusiveness of their workplace. This may inform predictions about staffing retention in the future.

A total of 841 valid responses to the survey were received. Responses were collected from individuals working in direct healthcare (n=790), academia (n=58) and industry (n=35). Some respondents work simultaneously in more than one sector.

The following highlights just a selection of findings from the survey. More detailed findings, and a set of recommendations, will be published in due course.

Staff retention – workplace inclusion

The results highlighted areas of strength in the clinical engineering and medical physics professions, which should be celebrated. Across all respondents, 90% stated that their colleagues are generally supportive and 73% stated that they feel a sense of belonging at work. A theme of positive feelings towards colleagues in one's own team was identified from further comments.

However, concerning findings emerged regarding negative experiences with colleagues. A total of 23% of respondents have reported feeling bullied or harassed at their current workplace. This is comparable to the rates of bullying and harassment in UK workplaces generally and may be comparable to rates of bullying and harassment across the NHS. Rates of reported bullying and harassment are notably higher for those who are not HCPC-registered clinical scientists (32%), and those with mental health or neurocognitive disabilities (30%).

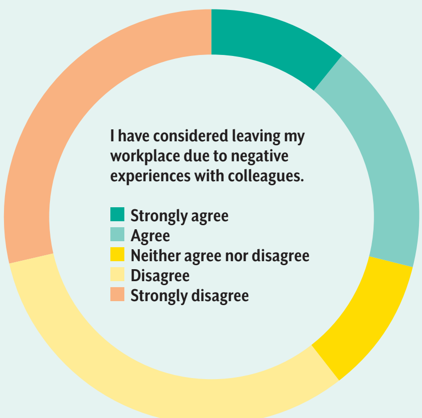


Figure ❶ The proportion of survey respondents who report considering changing jobs due to negative experiences with colleagues.

Moreover, a high number of respondents report considering changing jobs due to negative experiences with colleagues. Slightly less than 30% of all respondents agree that they have considered a job change due to negative experiences with colleagues: these rates are notably higher among women (41%) and respondents with mental health or neurocognitive disabilities (53%). Overall results are shown in ❶.

Conclusion

Staff retention in clinical engineering and medical physics has historically been high. This reflects a strength of the profession, but it must not be taken for granted. Care must be taken to ensure that all staff, particularly those with certain characteristics, are adequately supported and included within their teams.

IPEM will publish specific recommendations following these findings in due course.

FROM SCANS TO SOLUTIONS

How AI is revolutionising brain health

Senior Lecturer **Dr Moses Sokunbi** outlines how neuroimaging and AI are poised enable more accurate, timely and personalised diagnoses and treatments for brain disorders.

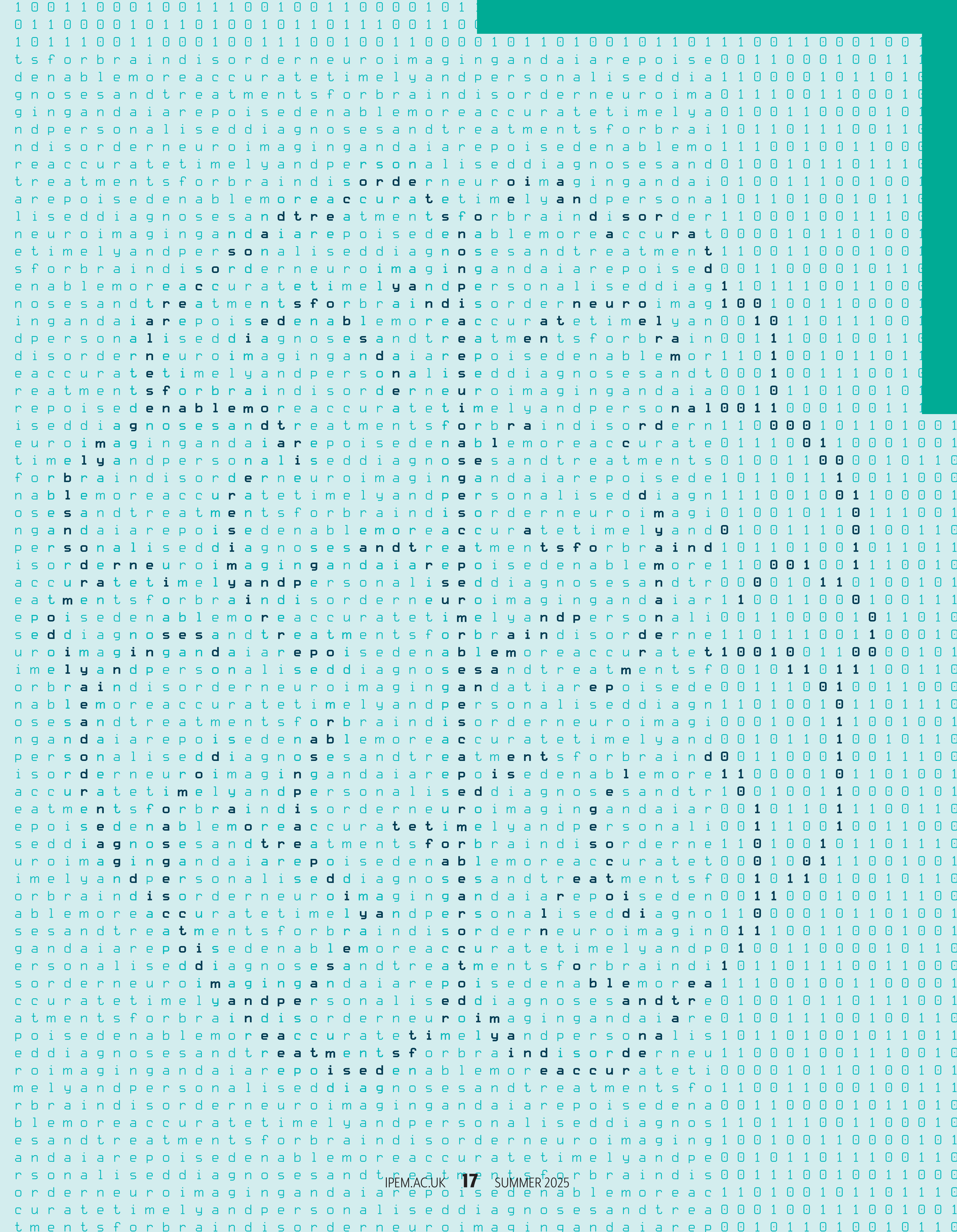
The human brain, with its intricate networks and complex structures, has long been a source of fascination and mystery. Over the past few decades, scientific advancements have allowed us to peer into the brain in unprecedented ways, leading to significant breakthroughs in understanding brain function and health. Among these advancements, the combination of neuroimaging and artificial intelligence (AI) stands out as a transformative approach that is revolutionising the way we approach brain health, diagnosis and treatment.

Here we will explore the ground-breaking techniques in neuroimaging, delve into the role of AI in processing and interpreting brain scans and examine how the fusion of these technologies is driving innovative solutions in diagnosing and treating brain disorders. We also highlight the ongoing work being done to use AI in predicting neural pathways in individuals with autism and discuss the promising future of this integrated approach.

Neuroimaging: a window into the brain

Neuroimaging refers to a range of techniques that allow scientists and medical professionals to capture detailed images of the brain's structure and function. These techniques are invaluable for understanding how the brain works and for diagnosing a variety of neurological conditions. Some of the most commonly used neuroimaging techniques include:

1. **Functional magnetic resonance imaging (fMRI):** This non-invasive method measures brain activity by detecting changes in blood flow. When a specific part of the brain is more active, it requires more oxygen, which causes an increase in blood flow to that region. fMRI captures these changes, providing insights into the brain's functional networks.
2. **Structural magnetic resonance imaging (sMRI):** sMRI provides high-resolution images of the brain's structure. It is particularly useful in detecting structural changes in the brain that occur in conditions, such as brain tumours, stroke, or neurodegenerative diseases.
3. **Positron emission tomography (PET):** PET scans are used to observe metabolic processes in the brain. By injecting a radioactive tracer, this method can detect abnormalities in brain activity, making it useful for diagnosing conditions like Alzheimer's disease or brain tumours.
4. **Electroencephalography (EEG):** EEG measures electrical activity in the brain, providing real-time insights into brain waves. It is often used in the diagnosis of epilepsy and sleep disorders.
5. **Magnetoencephalography (MEG):** This technique measures the magnetic fields produced by neuronal



activity. It offers a high temporal resolution and is often used to study brain function in real-time.

These neuroimaging techniques provide valuable data, but the complexity of brain images and the enormous volume of data they generate can be overwhelming. This is where AI comes in, offering powerful tools to interpret and analyse these images with greater accuracy and efficiency than ever before.

AI: The brain's new ally

AI techniques, particularly machine learning (ML), are transforming the way we process, interpret, and analyse neuroimaging data. Machine learning algorithms can be trained to identify patterns and correlations within vast amounts of data, allowing for faster and more accurate diagnosis of brain disorders. There are several types of AI techniques that are particularly useful in neuroimaging:

1. **Supervised learning:** The algorithm is trained on labelled data, meaning the input data is paired with the correct output. For example, an algorithm might be trained on fMRI images of healthy brains and brains affected by Alzheimer's disease. The model learns to differentiate between the two, allowing it to classify new, unseen data. Supervised learning is often used in diagnostic tasks, such as detecting cognitive decline or identifying brain tumours. Some examples of supervised learning are deep learning models, such as convolutional neural networks (CNNs) and long short-term memory (LSTM) and recurrent neural networks (RNNs).
   - **CNNs:** These are particularly effective in processing and interpreting images. CNNs are used to analyse fMRI and MRI scans by learning hierarchical features from the images. For example, CNNs can identify specific brain regions that are affected in diseases such as Alzheimer's or schizophrenia.
   - **LSTM and RNNs:** These types of neural networks are designed to handle sequential data, making them well-suited for tasks involving time-series data, such as fMRI scans that capture brain activity over time. LSTM-RNNs are able to model the temporal dynamics of neural activity, making them valuable in predicting brain network activity, such as in the context of cognitive decline or neurofeedback therapies.
2. **Unsupervised learning:** Unsupervised learning does not require labelled data. Instead, the algorithm identifies patterns and structures within the data on its own. This can be particularly useful in exploring unknown brain networks or discovering new biomarkers for diseases. For example, unsupervised learning could be used to identify previously unknown brain networks associated with depression or anxiety.
3. **Semi-supervised learning:** This technique lies between supervised and unsupervised learning. It uses a small amount of labelled data alongside a large amount of unlabelled data to improve model performance. This approach is valuable in neuroimaging as it allows researchers to make use of the large amounts of unlabelled data typically found in brain scans.

Synergy between neuroimaging and AI

The integration of AI with neuroimaging has opened up new possibilities for understanding and treating brain disorders. By combining the power of AI with the insights provided by neuroimaging, researchers and clinicians can now make more accurate predictions about brain health, detect diseases at earlier stages and tailor treatments to individual patients.

Some key areas where this combined approach is making an impact include:

1. **Predicting brain networks in disease diagnosis**

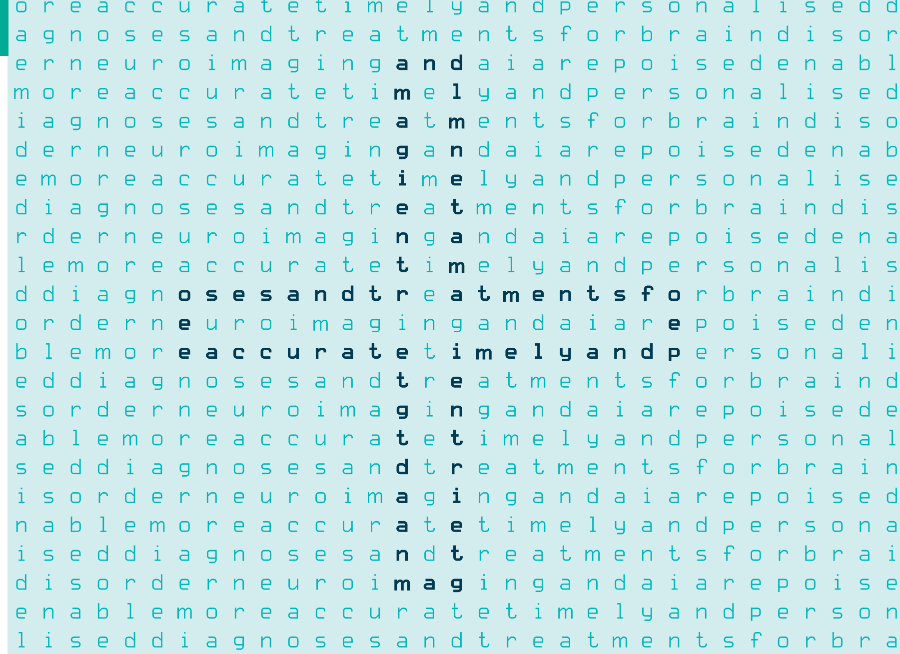
AI has the potential to revolutionise the diagnosis of brain disorders by identifying biomarkers and patterns in neuroimaging data that may be invisible to the human eye. In conditions such as Alzheimer's disease, fMRI scans can reveal changes in brain activity and connectivity. By using AI techniques such as CNNs and LSTM-RNNs, researchers can develop models that predict the progression of Alzheimer's based on early neuroimaging data. These models can help doctors identify at-risk individuals before significant cognitive decline occurs, enabling earlier interventions.

Similarly, in conditions such as depression, AI algorithms can analyse sMRI and fMRI scans to identify subtle changes in brain regions associated with mood regulation. This can help clinicians personalise treatment plans, whether through medication, therapy, or neurofeedback techniques.

2. **Personalised medicine and brain enhancement**

AI and neuroimaging are also being used to develop personalised treatment plans for individuals with brain disorders. For example, by combining fMRI scans with AI models, doctors can create brain activity profiles for patients, identifying specific regions that are underactive or overactive. This information can be used

> "THE POTENTIAL FOR EARLY DETECTION, PERSONALISED MEDICINE AND BRAIN ENHANCEMENT WILL ONLY GROW



to design targeted interventions, such as transcranial magnetic stimulation (TMS) or neurofeedback, to enhance brain function and promote recovery.

In the context of brain enhancement, AI is being used to optimise cognitive training programmes. By monitoring changes in brain activity through neuroimaging and adjusting the training regimen accordingly, AI can help individuals improve cognitive function, memory and learning abilities.

3. Neurofeedback and brain rehabilitation
Neurofeedback is a technique that uses real-time brain activity to train individuals to regulate their brain function. By combining neuroimaging data with AI, neurofeedback systems can be made more precise and personalised. AI algorithms can analyse the brain's activity patterns and provide immediate feedback, helping individuals with conditions like depression, ADHD, anxiety, or PTSD regulate their brain activity. This approach holds promise for brain rehabilitation, offering a non-invasive, drug-free alternative to traditional therapies.

4. Cognitive decline and ageing
As we age, cognitive decline is a natural process, but for some, it progresses into conditions such as dementia or Alzheimer's disease. AI is playing a key role in detecting early signs of cognitive decline. By analysing longitudinal fMRI scans, AI models can predict changes in brain networks that are associated with ageing. This can help doctors provide early interventions that may slow down or even prevent the onset of more severe cognitive impairments.

5. Brain tumours and other neurological disorders
The combination of AI and neuroimaging is also being used to improve the detection and treatment of brain tumours. MRI scans, when analysed with AI algorithms, can help identify the location, size and type of tumour, allowing for more accurate diagnosis and treatment planning. AI is also being used to predict the response of tumours to various treatments, such as chemotherapy or radiation therapy, helping doctors make more informed decisions.

The Impact on healthcare and the future of brain health

The combination of neuroimaging and AI is poised to transform healthcare by enabling more accurate, timely, and personalised diagnoses and treatments for a wide range of brain disorders. As AI models continue to improve and the amount of neuroimaging data increases, the potential for early detection, personalised medicine, and brain enhancement will only grow.

In my own research, which is an NIHR-funded study, I am using LSTM networks and RNNs to predict neural pathways in the fMRI scans of autistic adults. By identifying specific patterns in the brain's activity, this work aims to provide better insights into how autism affects the brain and ultimately improve diagnosis and treatment options for autistic individuals. This research could transform how autism is diagnosed and understood by using AI models (LSTM-RNNs) during brain scans to spot signs of autism in real time. This could lead to quicker, more accurate and more personalised support for each individual.

The future of brain health looks incredibly promising with the continued integration of AI and neuroimaging. As these technologies evolve, we can expect more sophisticated models, greater accuracy and the development of new therapies that will enhance brain health, improve quality of life, and offer solutions to previously untreatable conditions.

Conclusion

The fusion of neuroimaging and AI is revolutionising brain health by providing deeper insights into the brain's structure and function, improving diagnosis and enabling personalised treatment plans. From cognitive decline and ageing to brain tumours, depression and autism, the potential applications of this combined approach are vast. With ongoing advancements in both AI and neuroimaging, the future holds immense promise for brain health, offering new opportunities for diagnosis, treatment and enhancement that were once unimaginable. The work being done today is paving the way for a healthier, more informed future, where AI is not just a tool for diagnosis, but a critical partner in advancing brain health and medical care.

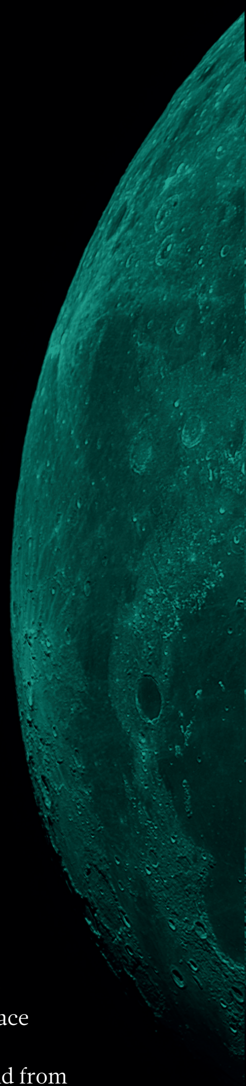
__Dr Moses Sokunbi__ is a Senior Lecturer at the Faculty of Health and Life Sciences, De Montfort University, Leicester. His areas of research entails using AI, brain-computer interfaces, entropy, fMRI and neurofeedback to map and understand the functioning of the human brain.

GENERAL FEATURES

ACADEMIA TO INDUSTRY

A view from the dark side

Inpictura founder **Dr Mark Gooding** gives some insights into the motivation behind his decision to start a company as an industrial scientist.



If I was to write an FAQ on being an industrial scientist, I'd have to start with the question "Why did you decide to move from academic to industry?" This question comes up so often over a beer in the evening at conferences. I figure much of the background to that question comes from an acknowledgement of a lack of experience or understanding of the role, but I also suspect that part of underlying question is "you seem like a nice person, why do you work for the dark side?" One of the curious things about the original *Star Wars* is that those of the Empire know that they are the "bad guys" even though they are the governing authority because they are using the dark side for the Force, while the Rebels, who are outlaws, are known to be the "good guys". If a stormtrooper sat down with a rebel fighter for a quiet beer and a chat, I can imagine the same kind of questions being asked "Why did you choose to join the [pick a side]?". However, we're not in that situation really, and I'd like to think that all of us – whether in the clinic, academia or industry – are trying to work collaboratively for patient benefit, rather than fighting each other for control of the galaxy.

Nevertheless, hopefully this article can give you a view from the dark side. And to answer the FAQ question – I'm personally motivated by doing engineering – designing and building things to solve problems. I feel like I've been successful in doing that when those solutions are being used in practice. I felt too far removed from seeing the solution used in the real world in academia, where the main output is the research publication about the solution. Industry seemed a place I could make a difference. The increased motivation I've found from moving to industry has also made me a better researcher (probably), and I'm very happy to be an honorary member of the Radiotherapy Related Research Group at University of Manchester as an outlet for my academic curiosity.

> "WHETHER IN THE CLINIC, ACADEMIA OR INDUSTRY – WE ARE TRYING TO WORK COLLABORATIVELY FOR PATIENT BENEFIT

My colleague Djamal, having spent half of his career as an academic and half in industry, always working on medical imaging related problems, is comfortable in either world. While his motivation is largely fed by the happiness he feels when he reaches an elegant solution to a

IMAGE: ISTOCK

challenging technical problem, he relishes the opportunity to teach, afforded by academia, yet also enjoys the knowledge that his work is making a difference to patients, given by industrial research.

Unlikely entrepreneurs

Now that we are running an independent company, the FAQ also adds additional questions regarding entrepreneurship.

Top of that FAQ is "Did you always want to start/run a business?". The answer to that is short: "no". If I'm forced to expand from a one-word answer, it was not on my radar at all until a few years ago. I view myself as an engineer/scientist developing solutions. I've never much liked talking about the financial side or getting involved in sales. I just want to be solving problems and helping people. So, you might then wonder how Djamal and I came to be starting and running Inpictura Ltd. To put it briefly, an unexpected opportunity to do interesting and useful work presented itself.

A few years ago, Mirada Medical, for whom Djamal and I both used to work, decided to focus on opportunities outside of the external beam radiotherapy market following the disruptive impact COVID had on the industry. As Chief Scientific Officer, having built a reasonably large team to develop innovative solutions in the space of radiation oncology, I found myself in the undesirable position of having to downsize that team. Consequently, I handed in my notice without any plan of what to do next. During the redundancy process I was rather struck by something that my colleague, Rebecca, said; that this was the best thing that had happened to her. That's not the expected response to being made redundant. Nevertheless, the role at Mirada had expanded her experience outside of what she had done previously and redundancy was giving her an opportunity to reflect on what she really wanted to be doing. It was time to reflect on what we were good at and what we wanted to be doing. I say "we" because whatever the next step was, Djamal and I wanted to be working together, if possible.

One thing was clear to me – whatever we did, it would be in the field of radiotherapy for several reasons: there is interesting technology development going on which allows for geeks like Djamal and I to be useful and we have experience in this field. While I have no doubt that Djamal and I could apply our skills to other areas of healthcare, it would take time to ramp up. Our experience in radiotherapy means we can be immediately useful and we already have strong connections in this field. We don't see this as a network to be "exploited", but rather our long-term collaborators who have become our friends and we want to continue working with.

> **"OUR AIM WAS ONLY TO BE HELPFUL AND TO BE ABLE TO PAY OURSELVES ENOUGH TO LOOK AFTER OUR FAMILIES**

Although rumours of Gooding Enterprises (G.E?) had started within Mirada, following its change of direction, that I would buy-out some of its radiation oncology technology, employ the same team, and continue what we had started, I had rather assumed we'd find other similar roles within another company in the radiation oncology world. Instead of either of those possibilities, we stumbled into Inpictura Ltd when another opportunity arose. Mirada was looking to rehome technology as part of its pivot and one of the deals on the table looked like it would need support from us for few years, as the inventors of the underlying technology. Following some discussions with the third-party company, it seemed that offering scientific consultancy through a company would be the easiest way to do this, and Inpictura was born.

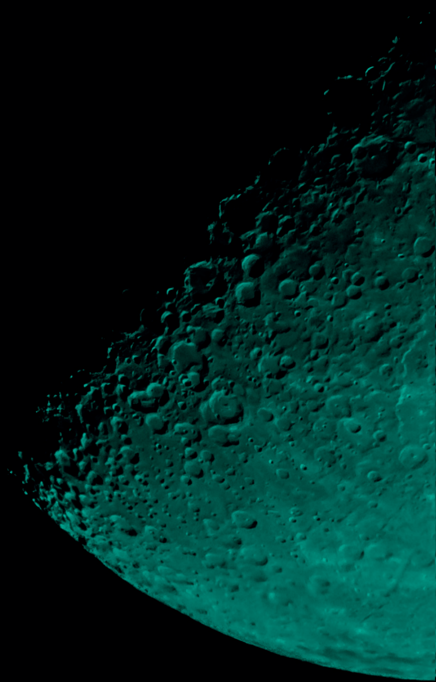
Finding the vision

A few years of consultancy could keep us busy and pay the bills for a while, but it's hardly a business plan. Knowing that I knew very little of starting and running a business, I bought a book, *Starting a business for dummies*, and attended a few training courses with Oxfordshire Local Enterprise Partnership (OxLEP). Few businesses are founded with a vision of "make lots of money" and then finding the way to do that. The "right way" to start a business is to have a product or service idea that meets a market need and then figure out how to turn that into a financially viable business. However, beyond the initial consultancy idea, Inpictura didn't really have a product/service idea. Our aim was only to be helpful and to be able to pay ourselves enough to look after our families. To make the idea work beyond that initial consultancy, we would need a plan – a product idea backed by a real business plan.

There are two broad philosophies that I've encountered when it comes to finding a product idea. The first is to find a problem that the wider market knows it has and then solve it. This is advocated by training programmes such as "Pragmatic marketing". Selling such solution should be easy since the market knows it has that problem and are waiting for a solution. The second idea is one of being "visionary" and anticipating a need that the market doesn't really know it has. This approach typically has the potential to be more innovative/disruptive but requires more market education – the problem needs articulating before the solution can be sold and typically has a longer adoption cycle. The book *Crossing the chasm* by Geoffery Moore describes the challenge of adoption well.

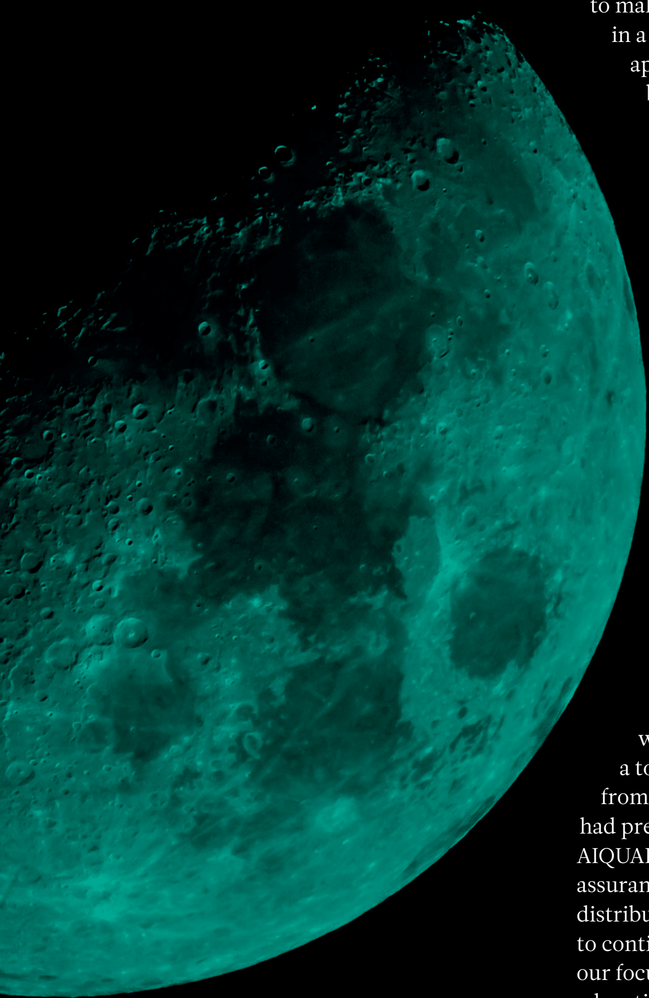
In practice the situation is never so binary. Take deep learning contouring (DLC) as an example of this. Manual contouring is known to be one of the barriers to an efficient radiotherapy planning workflow and existing "solutions" like atlas-based auto-contouring were limited in a number of ways. The innovation

IMAGE: ISTOCK



NHS CLINICAL ENTREPRENEURS

If you work within the NHS but have ideas for a product or company, I'd strongly recommend looking at the NHS Clinical Entrepreneurs scheme. This offers business education and support for would-be entrepreneurs and is specifically intended for staff working in the NHS to explore their entrepreneurial ideas.



offered by deep learning, meant the problem could be better solved. Thus, it could be assumed that should be adopted immediately. However, when Mirada first produced DLC in 2018, although visionaries and early adopters were quick to integrate the solution into clinical practice, there was still a need for market education in what "AI" was and the wider market waited while research studies and the experience of those early adopters validated its benefits. Nevertheless, adoption has been relatively quick over the past five years, and the substantial competition in this space currently highlights its market acceptance.

Djamal and I have always been better at the more academic end of product development and are more inclined to work with visionaries to help address problems that are emerging, rather than to make incremental improvements in a competitive market. So, our approach to developing ideas and a business plan was to speak with our existing collaborators and explore where we could be of help.

Our first product is an example of this. As AI automation is being more widely adopted, early adopters are starting to recognise the challenges/risks this technology can introduce and research is being conducted into how we do quality assurance. Quality assurance can fall into both the patient-specific type (is this patient's contour/plan correct?) and routine QA (is the product still performing as expected? Has anything changed in the workflow?). With the support of a grant from InnovateUK, we have been able to develop a tool for the latter following on from the collaborative research we had previously conducted in this area. AIQUALIS, a tool for on-going quality assurance of AI contouring, is now being distributed through PTW. In addition to continuing to develop this product, our focus must now be split to include education around the need – although this is substantially helped by the Royal College of Radiologist's excellent guidance of AI contouring in radiotherapy.

Aspirations for the future

Notwithstanding having a product on the market, our business vision hasn't changed substantially. Our website sets out our purpose as "to contribute to the improvement of medical imaging technology through meticulous research and generous collaboration, for the benefit of patients globally. To grow the company in a sustainable way to the benefit of both customers and all employees." Our primary focus remains being helpful, to our customers and collaborators, whether through product development or consultancy.

The beauty of our business plan, or apparent lack thereof, is that we are flexible. We will continue to develop AIQUALIS and we have a plethora of ideas on how that could be made more efficient and clinically insightful. At the same time, we remain open to new opportunities that allow us to continue to improve care for patients and grow the company in a financially sustainable way. It may be a little bit intentionally naïve, but we trust that by focusing on serving customers well, rather than focusing on sales and growth, we'll be able to generate enough income to remain financially viable.

Our intention from the outset has been not to raise external funding, such that the company can retain flexibility and to prioritise helping its customers. We also aim to grow the company because, as much as we like working with each other, we like working with teams and want the company to offer employment and personal development opportunities for the next generation. Although, the initial consultancy opportunity, which was the basis of Inpictura's founding, did not materialize, a combination of grant funding, consultancy work and very tolerant spouses has enabled us to bootstrap the development of AIQUALIS. We hope this, in turn, will facilitate growth over the next few years.

So now that I've given you an insight into the dark side, I'll put my helmet back on and go back to blasting away at those rebel scum...

I am delighted to have been awarded the IPEM Innovation Grant for the project "Implementation of ultrasound elastography quality assurance programme: a collaboration between the Institute of Cancer Research and the NHS". This award has enabled me to acquire experience in an alternative sector and link with a translational partner sharing knowledge and skills. The funds will allow us to invest in an elastography phantom, plus proper training and develop a quality assurance programme, including patient and public involvement.

Introduction

The idea behind the IPEM innovation project was born of personal experience. Over 15 years ago, I was diagnosed with a breast tumour. I had ultrasound imaging and surgery to have it removed. I soon realised this imaging modality does not get the credit it deserves. Ultrasound uses non-ionising radiation, it is accessible, inexpensive and does not require shielding considerations. Today, ultrasound scanners have evolved, offering improved quality, capability and applications. However, there are limited routine quality assurance (QA) checks and performance assessments of ultrasound protocols due to lack of resources. As highlighted by IPEM, ultrasound is an area in urgent need of investment to tackle current workforce shortfalls, and action should be taken to continue to provide safe, effective and patient-centred services in the NHS.

The aim of this article is to explore my initial experience of breast ultrasound elastography and share lessons learned through my own reflections, highlighting the importance of embedding patient and public involvement and engagement (PPIE) in any innovation project and service implementation in the NHS.

Ultrasound elastography

Ultrasound elastography is a non-invasive imaging technique that provides information about the elasticity of tissues. It uses a compression source to apply force to the tissue and an imaging system to display the resultant tissue displacement.

Ultrasound elastography systems are divided into two main categories: 1) strain-based techniques, which use static forces manually applied by the sonographer or radiologist to assess the resultant tissue displacement, and 2) shear wave techniques, which apply dynamic forces using a sequence of intense focused ultrasound pulses by the transducer to generate shear waves in the tissue. Shear wave elastography is less operator-dependent and the velocity of the induced shear wave is used to derive the Young's modulus, which is a quantitative measure of elasticity. Elasticity results are displayed as a colour-coded, real-time elastography map for different tissue types. This allows quantification of mechanical and elastic tissue properties.

Ultrasound elastography is mainly used for breast and liver imaging and has the potential to detect abnormalities and aid diagnosis. In the liver, ultrasound elastography can be used for assessing fibrosis and cirrhosis. In the breast, malignant tumours, such as invasive ductal carcinomas, tend to exhibit increased stiffness compared with surrounding normal tissue. Conversely, benign breast lesions, such as fibroadenomas, tend to be less rigid. This reduces the number of biopsies and unnecessary X-ray imaging, thereby saving costs to the NHS and reducing patient anxiety. The clinical benefits of ultrasound elastography are unquestionable. When used in combination with B mode ultrasound, it increases diagnostic confidence and specificity, helping

IMAGE: ALAMY

ULTRASOUND ELASTOGRAPHY

Public perception and awareness

Clinical Scientist **Virginia Marin Anaya** discusses her award-winning project on ultrasound elastography quality assurance.

clinical decision-making, and potentially speeding up treatment, thereby improving patient outcomes.

However, there is no routine QA of elastography protocols in ultrasound scanners due to lack of resources, equipment and expertise. Investment in an elastography phantom, plus proper training and the development of a QA programme, would alleviate the problem.

IPEM Report 102 was published in 2010 and provides recommendations in relation to ultrasound QA. It is hoped that a new and updated version of *IPEM 102*, including guidelines on ultrasound elastography, will be published soon.

The IPEM innovation grant has enabled patient and public involvement and engagement (PPIE) and collaboration across University College London Hospitals NHS Foundation Trust, the Institute of Cancer Research and the Royal Marsden NHS Foundation Trust, allowing us to share vital knowledge and skills that will further extend this benefit throughout the NHS. This will not only greatly improve the service we provide to patients, but it can also reduce mortality from breast cancer among women under 50. Women of this age range tend to have denser breast tissues and ultrasound can be more effective at detecting abnormalities than mammograms, differentiating between benign breast lumps and breast tumours, reducing the number of unnecessary ionising radiation. The types of cancer that develop in younger women tend to be more aggressive and progress more quickly. In these cases, earlier diagnosis and treatment could save the life of these patients. Furthermore, evidence suggests that Black and ethnic minority women are diagnosed with later-stage breast cancer at a younger age and have a higher mortality rate than white women. Breast ultrasound elastography has the potential to address this, reducing mortality and health inequalities.

The extent of health inequalities in the UK is largely hidden to patients and the general public, and without public awareness, it becomes easier for politicians and policy makers to ignore the problem in the face of more pressing matters. By embedding PPIE and building a collaboration with patients as equal partners we ensure that everyone has a role to play in shaping our NHS services.

Breast cancer

According to Cancer Research UK, breast cancer is the most prevalent cancer in the UK and the second most common cause of cancer death in females. It is more widespread in women over 50, but it can also affect younger women and to a lesser extent men. In the UK, one in seven women will experience breast cancer in their lifetime.

The NHS Breast Screening Programme was established in 1988 and invites all 50- to 70-year-old women registered with a GP for a mammogram every three years. The programme aims to reduce mortality

HERE ARE SOME OF THE LESSONS LEARNED FROM PATIENTS AND MEMBERS OF THE PUBLIC:

- Most women find having an ultrasound scan a better experience than a mammogram. They find ultrasound more reassuring, pleasant, personal and linked to a calmer environment. They like having the human connection and opportunity to ask questions.
  "I like ultrasound because you see results on the screen."
- Women with experience of contrast-enhanced mammography found it stressful or even scary because they do not like needles. Many considered mammography unpleasant or even painful.
  "I don't like it at all when my boobs get squished."
- Women find the waiting time for the results of their mammogram stressful and made them worry about breast cancer.
  "Waiting for the results of the mammogram causes me a great deal of anxiety. I lost my mother to breast cancer. Cancer is always in the back of my mind."
- In general, patients and members of the public were not aware of QA of medical equipment, such as ultrasound scanners.
  Once explained, they understood the difference between maintenance and routine QA. Patients think that QA is very important but recognise the constraints of limited time and resources within the NHS. Patients do not mind if QA is performed by NHS or subcontracting, they just want ultrasound scanners that work accurately and are fit for purpose. They want an ultrasound elastography QA programme to ensure that the elasticity values displayed are accurate. They would welcome the idea of a displayed certificate or sticker attached to the scanner to ensure that QA has been performed recently. Transparency would improve public trust.
- There is variability between manufacturers due to their unique implementation of the algorithms forming the elastography function. Patients worry that companies are businesses for profit. Patients would like to see collaboration between manufacturers and the NHS to ensure that images and the displayed elasticity values meet the necessary standards for accurate diagnosis.
- In general, women think that the current screening process is old and obsolete. They also feel that their personal and comfort levels preferences are disregarded, negatively impacting on breast cancer screening attendance. Most women thought that personalised breast cancer screening made more sense than screening based on age alone, and it was a good way of prioritising scarce NHS resources.
  "It makes sense that screening is based on personal factors. Age is just a number."
  "They should increase the frequency of screening for women allocated to the high-risk group. This would make them feel like they matter."
  However, some women were concerned about the quality of the risk stratification screening model, failing to embrace equality, diversity and inclusion. They worried that risk-stratified screening was yet another strategy to reduce costs in the NHS, which could potentially lead to more healthcare inequalities.
- Women would like to see transparency

"

THIS HAS THE POTENTIAL TO REDUCE MORTALITY AND HEALTH INEQUALITIES

through early detection. However, although the risk of cancer increases with age, cancer does not respect someone's 50 birthday. Current breast screening in the UK also assumes that mammography is the best imaging modality for all without taking into consideration breast density or personalised risk-stratified screening. This "one-size-fits-all" approach assumes that women are homogeneous, and that breast screening only works after age 50; this adversely affects Black, ethnic minority women, those with dense breasts and people with a BRCA1, BRCA2 or TP53 gene mutation. Moreover, this current approach "forgets" people that are not registered with a GP.

Breast screening is suitable for some LGBT+ people, but they may not receive an invitation letter since it depends on how their sex is registered with their GP.

Furthermore, Cancer Research UK has raised concerns over a decrease in the number of people participating in cancer screening. Breast screening uptake remains below the achievable performance threshold in all UK nations. In England only 65% of eligible individuals participated in breast screening in 2022–23. This participation rate is much lower than in other European countries: for example, in Denmark, where mammograms are offered every two years, the participation rate in 83%.

Risk-stratified screening, which divides the eligible population into groups based on their risk status, is currently being considered for national breast cancer screening programmes. It has not yet been implemented in Europe, but it is likely that other European countries will move towards more personalised screening rather than maintaining the existing one-size-fits-all age-based programmes.

indicating that multi-ethnic groups have been included in the model. They also want more information on the distinction between high and low risk.

Women identified as high risk of developing breast cancer will experience increased anxiety about cancer that may never develop. Conversely, women identified as low risk may become complacent and may not attend their screening invitation. If the screening interval for women at lower risk is extended, they may be less likely to receive benefit from screening.

"I think it is important to give people information so that they can decide and make their own choices."

- Some people did not attend the breast screening mammography invitation. Reasons for not participating are complex and include putting other people's needs ahead of their own, frequently prioritising their husband's, partner's and children's needs. Other issues that have prevented women from attending are logistic problems, such as lack of transportation, being very busy at work, limited English proficiency, cultural barriers, fear and shame, mistrust of the healthcare system and lack of breast awareness. Some people do not get paid that day if they attend breast screening. For some LGBT+ people, the main barriers to breast screening are privacy fears, lack of representation in information leaflets, and previous experiences of discrimination due to unconscious biases and stereotypes.
  "Breast awareness should be promoted."
- Patients welcome the concept of bringing the NHS to the people rather than the people to the NHS. It is likely that the provision of community diagnostic centres will increase over the coming years, including bringing cancer screening to the community. Patients think that this may improve access and attendance, reducing health inequalities for people from underserved groups and people with disabilities. It would allow them to bring a friend and feel more reassured.
  "I wouldn't have to take time off from work or worry about childcare."
  However, although patients and the public are supportive about community diagnostic centres, they also feel anxious about reductions in hospital services.
- Perceptions around AI vary and are heavily influenced by the media. In general, patients would welcome the aid of an AI tool to detect lesions and speed up the diagnosis if a clinician reviewed the images.
  "If it can save time, then it would be a no-brainer not to use it."
  AI software could free up clinicians' time to care for patients. However, they would like transparency in the models to ensure that they are inclusive and representative of the population they want to address. Patients worry that AI could potentially worsen inequalities.
  Despite increasing recognition about the importance of a diverse workforce, representation of women in leadership and senior positions within AI and digital transformation remains low. This negatively impacts on public trust in the AI tools being developed in healthcare, highlighting the need for more effort to achieve equity, diversity and inclusion in this key area.
- In general, people are not aware of medical physicists working in the NHS. This highlights the need for public engagement to raise awareness of the medical physics and clinical engineering workforce among patients and the general public, strengthening professional identity and breaking stereotypes.

Following a personalised assessment of individual risk level of developing breast cancer could open the possibility of changing the ages and frequency women are invited, as well as what imaging modalities are offered. Ultrasound elastography combined with B mode ultrasound could be one of these imaging modalities. By further tailoring screening based on relative risk, it can be possible to achieve better outcomes than under the current approach. This is not, of course, without challenges.

The UK National Screening Committee, which is the body that makes screening recommendations to the government, has work to do to ensure a good risk stratification screening model which is safe, ethical, and effective for all participants.

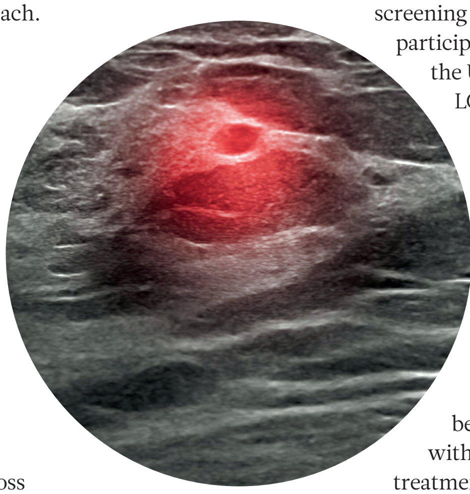
Patient and public involvement and engagement (PPIE)

If we are implementing a risk-stratified breast screening programme in the NHS, which can include ultrasound elastography, we have a moral obligation to make sure that we are involving patients and the public in the design of it, building a culture of inclusion across all aspects of the service. This includes working with patients to design an ultrasound elastography QA programme, thereby addressing patient concerns. By embedding PPIE, we can ensure that the service is developed in a way which is fit for purpose, addressing any potential barriers and reservations.

In my PPIE activity, I wanted to find out what patients thought and how they felt about breast ultrasound elastography and the possible use of AI as an aid to help clinicians identify lesions on the ultrasound images. I also wanted to find out more about people's attitudes towards risk-stratified breast cancer screening and understand barriers towards equity in healthcare. I included both eligible and non-eligible women for breast screening, breast cancer patients, and women of a diverse range of backgrounds. Sessions were held on Zoom or in person.

Summary and final reflections

Elastography is a non-invasive imaging technique used to assess tissue stiffness. There are currently no routine QA checks on ultrasound elastography. B mode ultrasound in conjunction with ultrasound elastography can be used to check breasts and axillae, to distinguish between a solid tumour and a cyst, and/or to check a lump that has not shown up on a mammogram. Patients and members of the public would like the development of a QA programme that checks that the elasticity values displayed on the screen are accurate and the scanner functions as expected.



Current breast screening programmes only offer a mammogram to women over 50. It is expected that future screening programmes should include risk stratification and personalised breast cancer screening, which might include elastography in addition to B mode ultrasound (for instance, in women with dense breasts, younger women and those with small breasts). At this stage, we cannot predict whether risk-stratified screening would potentially attract or deter eligible participants. Across many aspects of people's health in the UK, women of multi-ethnic backgrounds and LGBT+ are found to have worse outcomes and experiences than white heterosexual men. These health inequalities, avoidable and unfair, can have significant repercussions and influence trust in the NHS services. Positive patient experience is key for successful implementation of a service.

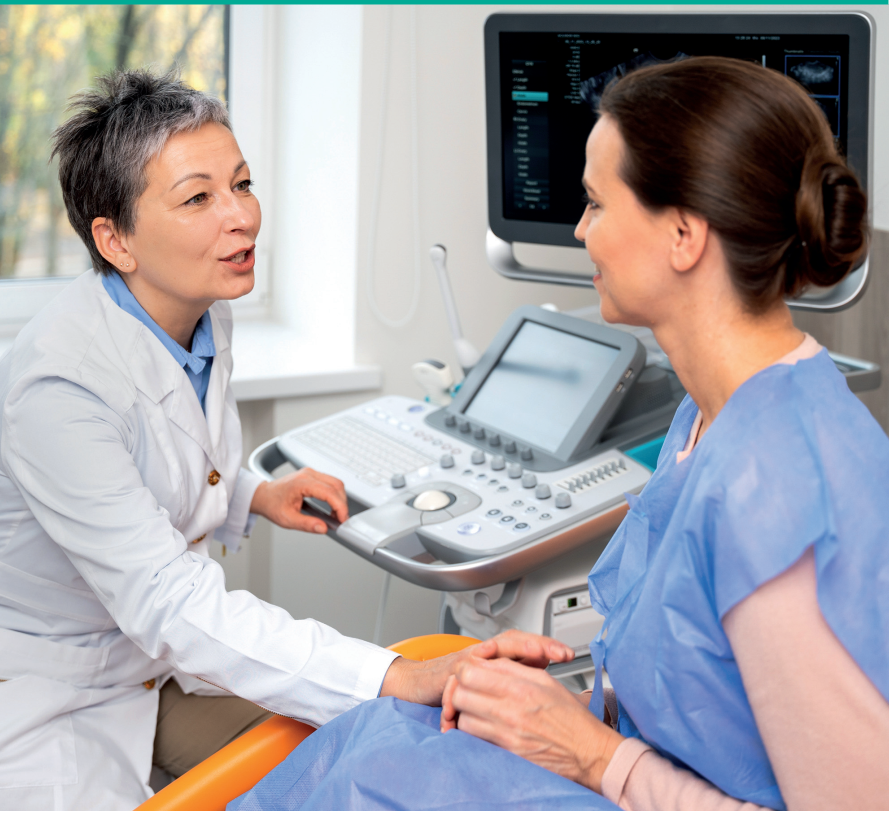
The Darzi Report highlighted health inequalities as a particular area of concern. Women from South Asian, Caribbean, and African backgrounds have been found to be more likely to be diagnosed with breast cancer at a later stage, when treatment is less likely to be effective, resulting in a higher mortality rate across these groups.

The objective of the WHO Global Breast Cancer Initiative is to reduce breast cancer mortality by 2.5% per year, thereby avoiding 2.5 million breast cancer deaths worldwide between 2020 and 2040. Breast cancer awareness is crucial, and this is where patients' personal cancer stories can be catalysts for influencing positive change and improvement. Some celebrities have shared their experiences, which are very powerful.

The American actress Angelina Jolie spoke openly about carrying the BRCA1 gene mutation

ACKNOWLEDGEMENTS

The IPEM Innovation Grant is about more than funding; it is about outreaching, learning, building networks, forging partnerships with other organisations, being inspired, and creating future collaborative opportunities, fostering a culture of innovation and adding value to the NHS. I am immensely grateful to IPEM for funding this project which recognises the importance of QA and multi-disciplinary collaboration. I would like to acknowledge The Institute of Cancer Research which was instrumental in advocating for this innovation project. I would like to thank Emma Harris, Jeff Bamber, John Civale, and Mark O'Leary at The Institute of Cancer Research and The Royal Marsden Hospital for their help and support. And last but not least, a big thank you to all patients and members of the public who contributed to this project. PPIE is about giving a voice to those people who may often feel invisible, forgotten or overlooked.



and highlighted the difficult decisions women with such mutations face. She underwent a preventative double mastectomy, raising awareness of the risk of developing cancers and importance of genetic testing. Christina Applegate, another Hollywood actress, also shared her personal experience of having an MRI scan and being diagnosed with breast cancer in her 30s. She highlights the importance of early detection and encourages women to participate in breast screening.

Another advocate for breast cancer awareness is the Australian pop singer Kylie Minogue, who was diagnosed with breast cancer in her late 30s. She actively participates in campaigns and fundraising events, supporting various breast cancer charities.

Not all breast cancers present as palpable lumps. The American author Kristin Hannah in her novel *Firefly Lane*, now a major Netflix series, raised awareness of inflammatory breast cancer (IBC) after losing her own mother to the disease. IBC, a type of invasive ductal carcinoma, is rare, but dangerous because it often does not cause a breast lump and may not show up on a mammogram. IBC is often misdiagnosed and by the time it is recognised it is too late. This disease tends to occur in women under 40 and is also more prominent among Black women.

With a budget tighter than ever, it is difficult for the NHS to prioritise the issues that matter most. The NHS recently reported a 5% increase in cancer diagnoses. Early detection is key to saving lives. However, according to Cancer Research UK, currently only 54% of cancers are diagnosed at stages I or II. Screening and awareness campaigns should be promoted if we are to achieve the target set up by the government to diagnose 75% of cancers at stages I and II by 2028.

IMAGE: ALAMY, SHUTTERSTOCK

Conclusion

The NHS is facing unprecedented demand and pressures. Change is needed to retain staff, address record-low levels of public satisfaction and improve services for patients. The new government is producing the *10 Year Health Plan* in an attempt to make the NHS "fit for the future". The plan for reform sets out three shifts: 1) moving from analogue to digital, including AI solutions, 2) shifting care from hospital to community care, including community diagnostic centres, and 3) shifting focus from treatment to prevention, including cancer screening.

At this stage, it is unclear how these changes will happen in practice. New technology is being developed, including AI which can be used as a triage tool and help clinicians with detection and diagnoses, freeing up resources. However, adoption and implementation in clinical settings are usually not simple and require a multi-disciplinary approach and collaboration.

Medical physicists and clinical engineers play a vital role in the evaluation, assessment, and commissioning of new techniques. Yet, many people, including many NHS staff, are unaware of the healthcare science workforce within the health service. This lack of awareness can be partly attributed to the highly specialist nature of our work, the tendency to work in silos and be in hospital basements with little interaction with other staff. It is clear we are aware that healthcare scientists' work is hidden to the general public. I would like to lobby for change by encouraging collaboration with other departments and translational partners, bringing different skills and perspectives, and embedding PPIE in our work, thereby empowering patients and the public and raising awareness of the role of clinical scientists in the NHS.

The NHS is much more than doctors and nurses. Healthcare scientists are the driving force behind the NHS's ability to adapt to the rapidly evolving technological landscape, fostering a culture of innovation and shaping the future services. Innovation is essential if the NHS is to cope with rising demand over the coming years. It will also be a key-enabler of the three shifts the government wants to see. Innovation can reshape clinical pathways, moving us beyond one-size-fits-all to a more personalised approach. By focusing on each patient's unique needs, we can potentially achieve earlier detection, diagnosis and treatment, minimising unnecessary interventions and improving patient outcomes in the NHS.

Virginia Marin Anaya *is a Clinical Scientist at University College London Hospitals NHS Foundation Trust, an IPEM AI Group Member, a BIR Radiation Safety Committee Member, an NIHR Innovation Fellow (Cohort 2), a Topol Digital Fellow (Cohort 4) and a STEM Ambassador.*

SHAPE THE FUTURE

British Standards Institution

In the first instalment of a new series, **Stephen Rac**, Standards-Makers Communications Manager at the British Standards Institution (BSI), looks at shaping the future of the profession and how IPEM members can get involved.

Standards are all around us. Whether it's medical devices, the cars we drive or the design of the furniture in your home, standards play a crucial role in making sure the world around us runs safely and efficiently. If you are interested in becoming a driving force in the direction of your industry whilst also gaining experience and forging connections to support your own career aspirations, getting involved with standards could be for you.

IMAGES: NOUN PROJECT

What are standards and why do they exist?

Standards impact us all every day – often in ways we never notice. Essentially, they exist to provide guidelines, recommendations, specifications, or requirements in how to do something well, consistently. From designing a product, managing a service, harvesting the food we eat, or even making whiskey, standards help shape a fairer, more sustainable future and help tackle global issues.

Standards cover a variety of areas, such as AI, net zero and mental health and wellbeing in the workplace and can equip businesses and individuals with the knowledge to improve quality, safety and sustainability in their area of work. In turn, standards enable businesses to experience the organisational benefits of this, such as growth, market access, business process improvements and cost savings, to name but a few.

What is BSI?

BSI is appointed by the UK Government as the National Standards Body and represents UK interests at the International Organization for Standardization (ISO), the International Electrotechnical Commission (IEC) and the European Standards Organizations (CEN, CENELEC and ETSI).

As the UK's national standards body, BSI is responsible for enabling and facilitating the development of standards in areas such as medical devices, healthcare, innovation, digital, sustainability and more. We do this by bringing together over 13,000 diverse UK stakeholders and interests from government, academia, and industry and support them to develop standards that address future and current business and societal needs.

BSI provides organisations with the confidence to grow by partnering with them to tackle society's critical issues – from climate change to building trust in digital transformation and everything in between – to accelerate progress towards a fair society and a sustainable world.

What are the benefits of getting involved with standards?

There are a huge number of benefits to getting involved with standards:

- Opportunity to contribute to the public good and shape the future of your industry by helping to shape standards at the national and international level by becoming a standards maker.
- Learn about which standards can bring agreed good practice into your organisation to help improve anything from accessibility to net zero and everything in between.
- Gain insight from the UK's national standards body – a purpose-driven organisation at the forefront of positive societal change.
- Develop key professional skills, including communicating with impact, consensus building and negotiating.
- Forge new connections with other leaders and experts, both within and outside your industry.
- Opportunity to attend high-profile standards-focused events, including the annual Standards Conference and Young Professionals Exchange.

How do standards affect my industry?

There are lots of standards covering medical devices and engineering, perhaps the most prominent of which is the IEC 60601 series. This is a series of international standards that pertain to the basic safety and essential performance of medical electrical equipment, including but not limited to:

1. **Medical electrical equipment:** This includes everything from infusion pumps and defibrillators to linear and MRI scanners.
2. **Medical electrical systems:** A combination of medical electrical equipment that may also include certain non-medical electrical equipment that are interconnected. For example, a battery-operated patient monitor with its charging dock or a CT scanner with its control computer.
3. **Medical software:** This category includes software applications and systems used in medical devices, such as patient monitoring devices, diagnostics, software and electronic medical records.

How can I get involved?

There are a few ways you can get involved in standards development, each of which are vital to the process.

1. **Become a standards maker:** The most direct and beneficial way in which you can get involved in standards

> "BSI PROVIDES ORGANISATIONS WITH THE CONFIDENCE TO GROW BY PARTNERING WITH THEM TO TACKLE SOCIETY'S CRITICAL ISSUES

A STANDARDS MAKER'S PERSPECTIVE

Clearly, we think getting involved with standards is a great idea, but don't just take it from us. Hear from Abdul Sayeed, a BSI Committee Chair who shared his views and experiences of the benefits of joining a BSI Committee:

"Through my involvement in standardisation activities, I have gained valuable insights into the safety aspects of manufacturing, which are crucial for creating safe and effective products. Collaborating with colleagues from around the world has expanded my global working experience, offering a unique platform to learn about diverse working practices and cultures. This has deepened my understanding of global standardisation.

"Moreover, I have had the opportunity to network with numerous experts, enhancing my professional connections and accessing a wealth of knowledge and expertise. Engaging in standardisation activities has not only broadened my professional horizons but also contributed to the development of industry-wide best practices.

"I strongly encourage everyone to participate in standardisation activities. It is an excellent way to stay ahead in your field, contribute to the creation of safer and more effective products, and build a robust professional network. The collaborative environment and exposure to global standards will significantly enhance your skills and career prospects."

Abdul Sayeed – Chair, BSI Committee CH/62 Medical Equipment, software and systems.

development is by applying to become a BSI Committee Member, or "standards maker". Our standards makers enjoy the full value of all the benefits outlined above whilst contributing to our shared vision of creating a fair and sustainable future for all.

You can find out more about joining committees by visiting **b.link/ns3r8dfw**

If you have any questions about joining committees or any aspect of the standards development process, feel free to get in touch with us by email at **standardsmakers@bsigroup.com**.

2. **Comment on a standard:** Before publication, all standards go through a public comment stage, during which all interested stakeholders are invited to read a draft version of the standard and make suggestions for anything they think should be changed, added or omitted.

This is a great option for anyone who would like to influence the standards that affect their industry but perhaps are not able to commit to full committee membership. To find draft standards available for public comment, visit the Standards Development Portal: **b.link/0zvux59w**.

2. **Suggest a new standard:** If you have identified the need for a new standard in your area of expertise, you can submit your proposal to our standardisation experts. The team will then contact you directly to let you know whether or not BSI is able to take your proposal forward and, if so, the process for turning your idea into a new British Standard.

Proposals for new standards be submitted through the Standards Development Portal via the same link as above.

You can also explore the BSI Knowledge Portal (**b.link/hol44yi2**) to search for and learn about standards that might be relevant to your work, organisation, knowledge or interests.

IEC Young Professionals Programme

Every year, BSI offers young engineers the opportunity to participate in the IEC Young Professionals Programme (IECYPP), a prestigious professional development programme led by the International Electrotechnical Commission (IEC), the world's leading organisation for the preparation and publication of international standards for electrical, electronic and related technologies.

The IECYPP is integrated into the annual IEC General Meeting (GM), a week-long event where global stakeholders tackle critical challenges and set the strategic direction for the IEC. This year, the 89th IEC GM will be held in New Delhi, India from 15 to 19 September and successful applicants will be part of the event, all expenses paid.

The 2024 IECYPP participant Tom Ruddell had this to say about his experience taking part in the programme: "Once I got over my initial nerves I had a great time meeting people from across the world, each with unique and fascinating experiences and (I hope) some of those will go on to become lifelong friends and colleagues. I do believe that international standards have a vital role to play as we transition to a sustainable society – and by providing a common language and opportunity for collaboration, can only help reduce division and rebuild trust."

This is just one example of the plethora of opportunities available through standards. To find out more about the 2025 programme, visit **b.link/7q49tmfo**.

At BSI, we run our own YP engagement programme, providing opportunities for young professionals to access networking events and other career development opportunities. To find out more, including information on joining the BSI YP Network, email **standardsmakers@bsigroup.com**.

Career development, chances to grow your network and opportunities to make sure the world around us is a fairer, safer, more sustainable place for all, what's not to like? Why not get involved and see where standards can take you?

Don't forget, to find out more about getting involved you can:

- Visit **b.link/lt0k5s7m**
- Email **standardsmakers@bsigroup.com**
- Explore standards on **knowledge.bsigroup.com**

MEDICAL ENGINEERING APPRENTICESHIPS

Apprenticeship Training Manager **Omran Darr** on Leeds Teaching Hospitals reaching a milestone by employing its 50th medical engineering apprentice.

By September 2025, Leeds Teaching Hospitals NHS Trust will have employed more than 50 medical engineering apprentices. Since its launch in 2013, the Medical Engineering Apprenticeship Scheme at Leeds has enjoyed great success.

The medical engineering apprentices work in all the different disciplines within the medical physics and engineering department. These include clinical engineering, radiotherapy engineering, renal engineering, rehabilitation engineering and medical imaging engineering.

Why apprenticeships?

In 2013, the Medical Physics and Engineering department at Leeds identified a shortage of suitable candidates for band 6 registered clinical technologists. With an ageing workforce and demographic challenges, there was a clear need to develop a pipeline of future engineers. The decision was made to address this gap by implementing a Level 4 Healthcare Science Apprenticeship Programme, aiming to combine academic learning with on the-job experience in a specialised field.

Evaluating and selecting

Before choosing an apprenticeship provider to deliver the Healthcare Science Associate Level 4 apprenticeship programme, our Medical Physics department contacted two providers and scored each provider to see which one would give the best value to our apprentices.

Leeds Teaching Hospitals eventually collaborated with Avensys and Dudley College to design and deliver the Healthcare Science Associate Level 4 apprenticeship programme. Avensys provide expertise in medical engineering, while Dudley College offers academic support and resources. This partnership ensures the programme meets learners' needs and delivers a high-quality educational experience.

Key ingredients of success

Recruitment Strategy: The team implemented a robust recruitment strategy, including engagement with schools, attendance at careers fairs and targeted advertising across multiple platforms. This approach yields a high volume of applicants, ensuring a diverse pool of talent.

Omran Darr is the Apprenticeship Programme Lead for the Medical Physics and Engineering Department at Leeds Teaching Hospitals NHS Trust and says recruitment is 365 days a year. Omran was awarded the IPEM 2024 Spiers's Award for Outreach for his work in improving education and raising awareness of medical physics and engineering. Omran says his role is challenging and he has enjoyed being able to reach out to the local community, the local schools and the local colleges to try and inspire the next generation of clinical technologists.

Our experience of having apprentices

Our medical engineering apprentices work in many different medical engineering disciplines, such as clinical engineering, radiotherapy engineering, renal engineering and rehabilitation engineering. Our apprentices develop a broad range of skills that prepare them for a successful career in their chosen area of medical physics and engineering.

Our apprentices will tell you that no two days are the same and how they enjoy excellent hands-on learning experiences which cannot be achieved through university. One of our apprentices says it's not every day you get a chance to fire X-rays out of a multi-million pound linear accelerator.

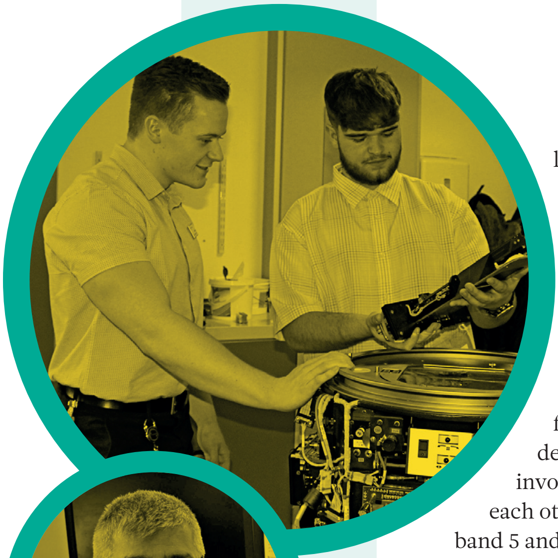
Career progression pathway

The apprenticeship programme focusses on careers not jobs. This helps with retention. Upon successful completion of the apprenticeship, apprentices are eligible to apply for permanent positions within Leeds Teaching Hospitals NHS Trust. Those who excel are encouraged to pursue further education and training, with opportunities to advance to higher level roles, such as band 6 registered clinical technologists via a level 6 apprenticeship.

The apprentices that have been through this career progression pathway are now working as band 6 senior lead clinical engineering technicians, band 6 specialist radiotherapy clinical technologists and band 7 technical team leaders. Over 75% of the apprentices that have been through this career progression pathway have also remained with Leeds Teaching Hospitals NHS Trust.

The apprenticeship programme fosters a culture of support and development with everyone being involved and apprentices supporting each other. Band 6 clinical technologists, band 5 and band 4 technicians also providing guidance to the apprentices. Having a dedicated apprenticeship programme lead ensures ongoing support and guidance throughout the programme.

Leeds Teaching Hospitals NHS Trust continues to invest in the apprenticeship programme, with plans to continue opportunities for career progression and further education. By nurturing talent and providing a clear pathway for advancement, the medical engineering apprenticeship pathway is building a strong and sustainable workforce for the future of the medical physics and engineering community.



Top and left: Those taking part in the Medical Engineering Apprenticeship Scheme at Leeds
Below: Omran Darr, the Apprenticeship Programme Lead

Recruitment and retention

Apprentice recruitment is arguably the most important aspect and requires continuous investment throughout the year. Our apprentice recruitment is apprentice-led with our apprentices attending careers fairs and apprenticeship fairs throughout the year. We historically get between 50 and 100 applicants per level 4 apprenticeship post. This includes a very high standard and a diverse range of applicants.

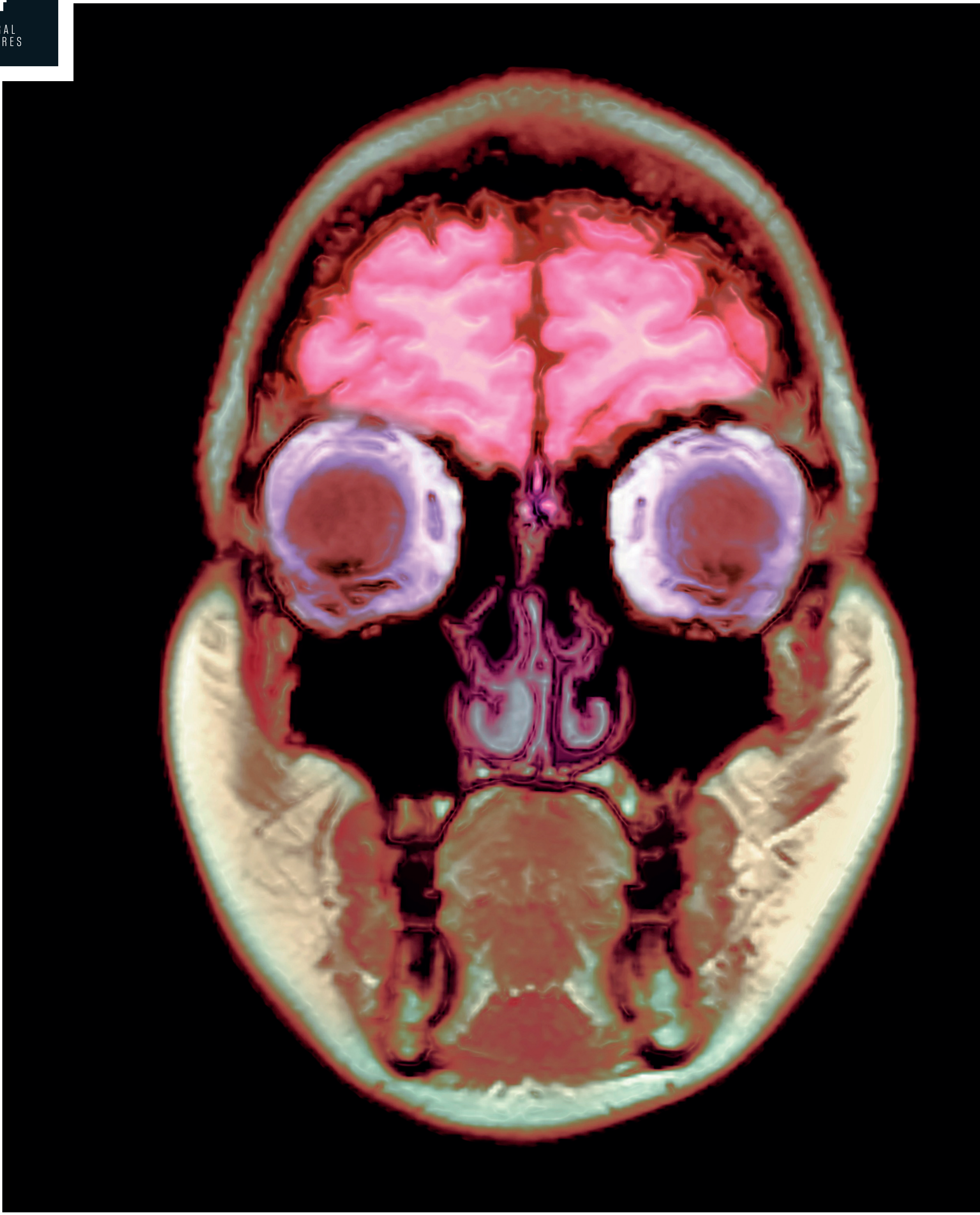
Apprentice retention is also very high within our department. A total of 29 apprentices have gone through the Level 4 Healthcare Science Apprenticeship Programme and 24 have obtained substantive posts within our Medical Physics and Engineering Department. We currently have an advert out now for six new apprentices to start in September 2025.

Reflections on taking on apprentices

Our advice here at Leeds Teaching Hospitals would be to engage with apprenticeship networks inside and outside of NHS. It is always good to have an apprenticeship programmed lead to deal with the day-to-day running of any apprenticeship programme. Having education and learning leads in the teams is also very helpful.

It is always good to engage with local schools, colleges, apprenticeship fairs, social media and hospital events about the work we carry out – let people know about what a fantastic and exciting career you can have in medical physics and engineering.

For more details about the *Medical Engineering Apprenticeship Programme*, visit **b.link/4izr6fg7.**



REFLECTING ON A JOURNEY

Publishing in a scientific journal for the first time

Clinical Scientist in Radiotherapy Physics **Sagar Sabharwal** outlines the process of publishing his first academic paper.

Last year, we published the MSc project I completed as part of the Scientist Training Programme in the *British Journal of Radiology (BJR)*. This was the first paper I've worked on. In stereotactic radiosurgery (SRS), a type of intracranial radiotherapy treatment, high-energy radiation beams are used to treat lesions close to healthy, sensitive organs, such as the optic nerves. This project involved taking MRI scans of volunteers looking in different directions to measure optic nerve motion. This measured motion data was used to create what is known in radiotherapy as planning organ at risk volume (PRV) margins for the optic nerves. PRV margins consider organ motion and other uncertainties in radiotherapy, such as how accurately and precisely a radiotherapy treatment machine, CyberKnife, in this case, can deliver a radiation beam to a point. When planning treatments, these margins are used as an additional safety margin around a healthy radiosensitive organ. The use of optic nerve PRV margins may help reduce the risk of radiation-induced optic neuropathy. This condition leads to progressive vision loss, and care is taken during radiotherapy treatment planning to keep radiation dose to the optic nerves below a tolerance level to reduce this risk. Our research findings provide a novel approach to determining optic nerve PRV margins for use with CyberKnife, the SRS system used at University Hospitals Birmingham (UHB), thereby improving the safety and efficacy of SRS treatments.

IMAGE: SCIENCE PHOTO LIBRARY

The project

I was drawn to this project as I wanted to work on something that could have a clinical impact. Additionally, the level of collaboration with colleagues from multiple disciplines that would be required for this project appealed to me. The project idea came from Dr Sanghera, a Neuro-Oncologist at UHB, and my project supervisor, Dr. Geoff Heyes, the Head of

"THIS EXPERIENCE HAS MADE ME WANT TO CONTINUE TO WORK ON RESEARCH PROJECTS

the Radiotherapy Treatment Planning department. My supervisor helped guide and support me throughout this project. For the magnetic resonance imaging (MRI) aspects of the project, I worked closely with Rob Flintham, one of the MRI physicists at UHB, to ensure the accuracy and reliability of our imaging data. I worked with Dr Sam Tudor on the margin calculations for this project, who is now the Head of the Radiotherapy Physics Department at UHB and has published work on margin calculations. I also worked with Professor Chavda, a Neuroradiologist at UHB, who assisted with reviewing contours and agreed to report on all MRI scans of our volunteers, as required by our trust ethics policy. This collaborative effort was crucial in ensuring the success and validity of our research.

We used NHS Research Authority tools to determine whether our project counted as research and whether an NHS Research Ethics Committee (REC) review would be needed. Our project counted as research, but did not need NHS REC review based on the results of these tools. This meant we had to go through our local trust's ethics process.

Address gaps

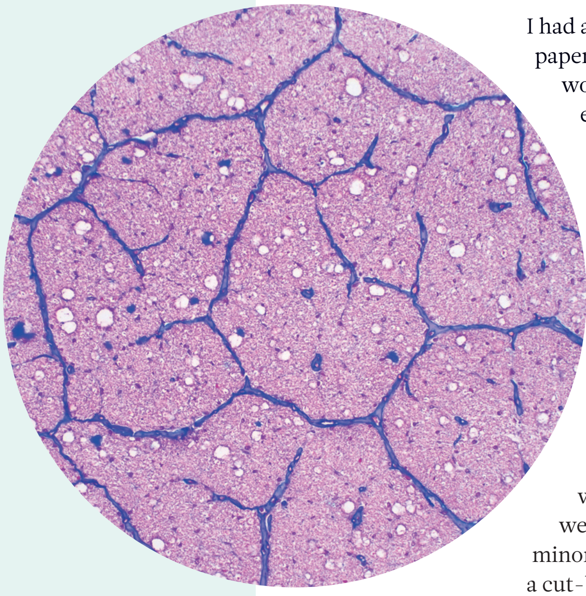
One of the key lessons I've learned from this experience is the importance of a thorough literature review and well-designed research questions. It's essential to conduct an exhaustive literature review to determine what research has been carried out previously and constructively critique the published literature. This allows you to refine your research question to help address gaps in the literature. I performed this literature review using PubMed and Google Scholar, searching for keywords related to our project. I completed a mandatory library course on conducting literature reviews at university. The knowledge from that course, particularly guidance around selecting keywords for searching, helped make this search a lot easier. Many NHS trusts and university libraries will have similar courses available to staff.

My supervisor, Geoff Heyes, and I used our literature review to help plan and design our research project. We wanted to focus this project on a specific topic with an end goal – optic nerve PRV margins for use with the CyberKnife radiosurgery system. We looked at similar work and used that to design our research methodology and find gaps to address. For example, we took the idea of having volunteers look left, right, up, down and straight-ahead during imaging from published literature looking at optic nerve motion. However, we increased the number of volunteers we imaged compared to some published work and chose to restrict eye motion when imaging using our eye position protocol. Previous work had asked people to look to the extreme edges of their vision to determine optic nerve motion. Still, we did not believe this to be a realistic scenario, so we wanted to limit eye motion further.

Key milestones

After completing our literature review, we divided the project into five key milestones and created a Gantt chart to map out our estimated completion time. The project was completed over about nine months, with a strict deadline for the MSc project. Once I had finished my dissertation, my

To read the paper in the *British Journal of Radiology*, visit the website **b.link/n1rx7res**



I had already written many aspects of the paper. However, cutting down 10,000 words to under 3000 words was not easy. My supervisor gave me some advice about approaching this. A dissertation involves a lot of describing, justifying, and explaining why things were done in a certain way. However, many of these aspects are left to the reader to judge in scientific papers; therefore, significant sections could be cut.

Reworking the paper

We had 14 drafts of the paper before we settled on a version we thought we could submit, albeit most were minor changes. Initially, the paper was a cut-back version of my dissertation. However, we realised formatting it like that didn't work, and the word count was still too high. Sam Tudor, who helped me with the margin calculations, suggested focusing the paper more on the margin calculations as this may benefit readers. Initial drafts of the paper were much less focused on the maths of margin calculations. I reduced the number of words spent talking about the MRI aspects of the project to focus more on margin calculations. This significantly improved the paper as we focused on something slightly more novel. There was already plenty of literature on MRI of the optic nerves, much of it published years ago.

Once we were happy with the draft, the manuscript was submitted through the journal submission process. A short while later, we received a confirmation that our paper was suitable for the journal and would be sent for peer review. A few months later, we received feedback from three reviewers. All the changes suggested were relatively minor; however, after discussions with others on the project, we decided to make changes that went further than those recommended by the reviewers. One of the reviewers asked for clarity about the margin calculation, and we decided the best way to do that would be to show our calculation step by step in a new table.

We then sent a new manuscript back to the journal for review. We heard back a few months later, stating our paper had been accepted for publication. The total time from beginning a literature review and forming our research question to publication was almost three years. For the first nine months or so, I worked on the project and wrote a dissertation to submit for my MSc. The rest was slowly writing a paper, with submission to *BJR* in early 2024 and publishing in late 2024. Writing the paper took much longer than I anticipated, mainly due to difficulties managing priorities. As a trainee, I had dedicated research time, but this is impossible while working as a clinical scientist, where clinical work will always come first. Gaining more experience has helped me manage my time much better, and I can communicate my workload to colleagues better when discussing non-routine and non-urgent work. I could have split my time more effectively and written the paper sooner than I did, and this is a lesson I will take with me on future projects.

supervisor suggested submitting abstracts to various conferences and starting on a paper. I presented this project at the annual meeting of the British and Irish Chapter of the International Society for Magnetic Resonance in Medicine in September 2022 and at the Institute of Engineering and Physics in Medicine Science, Technology and Engineering Forum in February 2023. Despite my initial nervousness about presenting to these audiences, I was greatly encouraged by the support and feedback from my department and during practice talks.

Aimed at both audiences

Before starting the paper, my supervisor and I discussed which journal we would submit the paper to. We needed a journal that would fit our research topic and was likely to accept our paper. Our project covered many aspects of medical physics, such as MRI, uncertainties in radiotherapy, and margin calculations for radiotherapy planning. We also thought this paper would be helpful to oncologists working in SRS. Therefore, the *BJR* made sense for us as it's a journal that publishes work aimed at both audiences. Picking a journal at the start of the writing process also meant we knew the author guidelines such as writing style, guidance on tables/figures and word count.

As this project was for my MSc, I had already written a dissertation, meaning

IMAGES: ALAMY, STUART BUNCH PHOTOGRAPHY

Expand the research base

Completing this project and seeing it through to publication has been an enriching experience, and it will positively impact my career moving forward. Being able to present at conferences has also helped me develop my presentation skills and confidence. Now that I work full-time as a clinical scientist, finding time to carry out project work can be challenging. The time from project completion to publication was much longer than anticipated, and this is something I'll aim to improve in future projects. This project was self-contained; however, it could be extended to look at optic nerve planning target volume (PTV) margin accuracy using the data we collected. In the meantime, I've joined a few other projects in my department we hope to publish. This experience has made me want to continue to work on research projects. As clinical scientists, I think it is essential that we try to expand the research base, whether through publishing in journals or presenting at meetings, alongside our clinical duties.

A version of this article first appeared in the summer issue of *The Healthcare Science Leadership Journal.*

MORAL INJURY: A RESPONSE

Utmost caution is required

Retired Clinical Scientist in Nuclear Medicine **T. Hawkins** responds to the article *"Navigating Moral Injury within the nuclear medicine environment"* from the Spring issue of *Scope*.

In the article "Navigating Moral Injury" (*Scope*, Spring 2025), Siobhan Mitchell looks at the routine and more specific risks to nuclear medicine staff. She poses the question whether these can amount to "moral injury", which, in the absence of a clear definition, might be considered akin to post-traumatic stress syndrome. The article cites the routine risks of staff shortages, long waiting lists, poor venous access, patient anxiety, claustrophobia and equipment failure. While these are real negative impacts, they have been ever present in many service departments and in no way exclusive to nuclear medicine. More specifically, she references the necessary dependence on radiopharmaceutical production and availability. The reliance on international supplies brings with it potential problems of arrival and expiry times and patient scheduling issues. The impact on staff and consequences for their psychological welfare are considered and possible lack of awareness of the concept.

My own 41-year professional career in a radioisotope section (later called nuclear medicine), both as a technologist and a clinical scientist suggests that we should be cautious about taking this route before a full characterisation of "moral injury" has been arrived at. My career ended before COVID years and I cannot reliably comment on its impact on staff and the sudden disruption of services, though I have not the least doubt the effect would have been keenly felt. But that episode

is behind us now and it may be worthwhile reviewing briefly the many developments in nuclear medicine over 60 years that have brought their own unwelcome stress during its period of existence.

In the mid 1960s nuclear medicine didn't exist as a profession in the UK, services being predominantly offered by medical physics departments. This was before the era of gamma cameras, when radioisotope scanners were the primary imaging device. Available radiopharmaceuticals: Iodine131, Sodium24, Xenon133, In113m, Gold198 and Phosphorus32 being among the few in use for diagnosis or therapy. The 1948 Radioactive Substances Act was not entirely appropriate for nuclear medicine imaging, its main thrust being for medical equipment – X-ray machines, radium therapy units, deep therapy X-ray units and superficial X-ray units.

With the arrival in the early 1970s of the molybdenum-technetium generator, Tc-99m, rapidly became the cornerstone of modern nuclear medicine due to its ideal properties for imaging. Radiopharmaceuticals were prepared on the open bench. Only meticulous cleaning between transfers stood between the technologists and a product sterility problem. Those dispensing procedures relied entirely on the principles of time-distance-shielding, fundamental to the radiation safety of the operator. The very high doses used in therapy carried an additional need for care and a calmness of approach.

The 1970s gamma cameras required daily testing and frequent tuning of the photomultipliers to ensure uniformity. Full or partial detuning could occur at any time and workarounds had to be made to avoid undue interruptions to imaging sessions. The arrival of the Ionising Radiations Regulations (1985) provided comprehensive guidelines for the protection of workers and the public from ionising radiation. A great many other regulations followed covering site registration, site authorisation, transport and waste disposal. The Ionising Radiation (Medical Exposure) Regulations 2000 set out heavy responsibilities for the safe use of ionising radiation in medical exposures. The Medicines and Healthcare products Regulatory Agency aimed to ensure compliance with Good Manufacturing Practice standards for the production of radiopharmaceuticals. Though open bench procedures had progressed into laminar flow cabinets, with arrival of GMP, even that was no longer adequate. Preparation in HEPA-filtered clean rooms with full gowning up became the established order. Each day became more challenging for the on-duty technologist or radiopharmacist. And with every regulation came inspection. Every new directive, each inspection, added responsibility to service departments and individual operators for ensured compliance and product quality.

" STAFF WORKED WITH THE DEDICATION AND PERSEVERANCE EXPECTED OF THEM – TRAITS THAT STILL ABOUND

Staff in most service centres will recall the regular pleas to department heads for additional staff and equipment owing to the rapid expansion of clinical demand. Those requests would usually be well behind time when such shortfalls were eventually met. Meanwhile staff worked with the dedication and perseverance expected of them – traits that still abound. The mother of all shortfalls appeared in 2008 with the simultaneous closures and temporary shutdowns of key nuclear reactors. This produced significant disruption to the supply chain of Mo-Tc generators. And it was not an overnight disturbance, it lasted some years. Those meagre supplies that did arrive had to be administered for the benefit of as many patients as could be managed. Sound planning and workarounds by staff once again saved departments from diagnostic shutdown. There have since been significant efforts to stabilise the supply of Molybdenum-99 (Mo-99), including: increased production capacity, diversification of sources, coordination and planning and regulatory support. These initiatives have significantly improved the stability of the Mo-99 supply.

In every one of these service disruptions, technical developments and regulatory obligations, there came an accompanying pressure for the team and individuals involved. And yet no recognisable hint of traumatic stress was seen. That is not to say staff did not feel the anxiety of challenging technical situations, an expanding catalogue of investigations and therapy, the strain of increased workload or the weight of regulation. Through individual resolve, supportive teamwork, imagination and good leadership at all levels, the worst possible outcomes on health, appear to have been avoided. If, as the author claims, there has been "an erosion of trust between healthcare professionals and leadership" then a resolution is indeed required. But deciding whether nuclear medicines specific issues are sufficiently peculiar to justify a defence of "moral injury" requires the utmost caution. Some would say we have seen such specific issues many times before.

IMAGE: ISTOCK

SOCIAL MOBILITY in education and the MPCE profession

IPEM EDI and Member Networks Manager **Eva McClean** looks at barriers that prevent young people engaging in science.

In the most recent *State of the Nation* report, the Social Mobility Commission highlights that social mobility in the UK is a complex picture and it distinguishes between occupation, income, education, housing and wealth. There are substantial differences in each area and in terms of region, ethnicity, gender and disability, meaning that although social mobility has been relatively stable, overall the outcomes for different groups are more nuanced.

Social mobility in education

In terms of education children from disadvantaged socioeconomic backgrounds are substantially less likely to reach the expected standards at all key stages. At GCSE level there is an average 27% gap between the poorest disadvantaged students and other pupils who achieve a grade 5 or above in maths and English. This gap has barely changed in the last 15 years, according to the Institute of Fiscal Studies.

There are important differences in this group of disadvantaged students, such as:

- A 70% variation across ethnicities.
- London outperforms rural and northern areas.
- Girls outperform boys.

These variances matter to our profession because achieving grade 5 or above at GCSE level is generally a prerequisite to study science A-level subjects. Research from the Institute of Physics found that students in the lowest socioeconomic quintile are three times less likely to take A-level physics than those in the top quintile. The Sutton Trust reports that schools with the most disadvantaged pupils are least likely to have teachers with relevant science qualifications, limiting the availability of A-level physics.

In addition to childhood poverty, parental education strongly influences attainment, with student success correlated to parents' qualifications. Inequalities and barriers at school level shape the population of science graduates as gaps between poor and rich children during school years can translate into differences in their qualifications as adults. About 70% of independent school students are university graduates by the age of 26, compared with less than 20% of children from the poorest fifth of households.

Social mobility in MPCE

Healthcare Science careers require a high level of education, which is appropriate given the nature of the profession. But what about social mobility and fair access? Is the MPCE workforce representative of the population?

When we asked social mobility questions in our recent State of the Profession survey, we found that in some areas this is not the case – 14% of medical physicists reported they went to an independent school. To put this in context – independent school attendance is 7% nationally and 22% among medical students. Medical physicists' parents also had more higher qualifications with 9% having a PhD and 12% a Masters degree. Only 2% of the overall UK population has a PhD. The technologist workforce reflects the national average more closely with 6% reporting they attended independent schools and 2% of their parents having a PhD.

So does it matter?

Health inequalities on a patient level are well documented. In terms of the MPCE workforce, should we argue that having a range of backgrounds mirroring patients and the general population would be beneficial? Could it build better connections to patients, offer different perspectives and solutions? Whatever your views, equitable access would certainly be fairer as healthcare science candidates should succeed based on merit, not privilege and educational advantages.

Given these substantial and structural educational inequalities there is, realistically, limited scope for us to create immediate change. However, events such IPEM's careers evening with the social mobility charity In2Science – targeted at students from low socioeconomic backgrounds – are helping our volunteer members and resources to play a role in widening participation in MPCE.

IMAGE: ISTOCK

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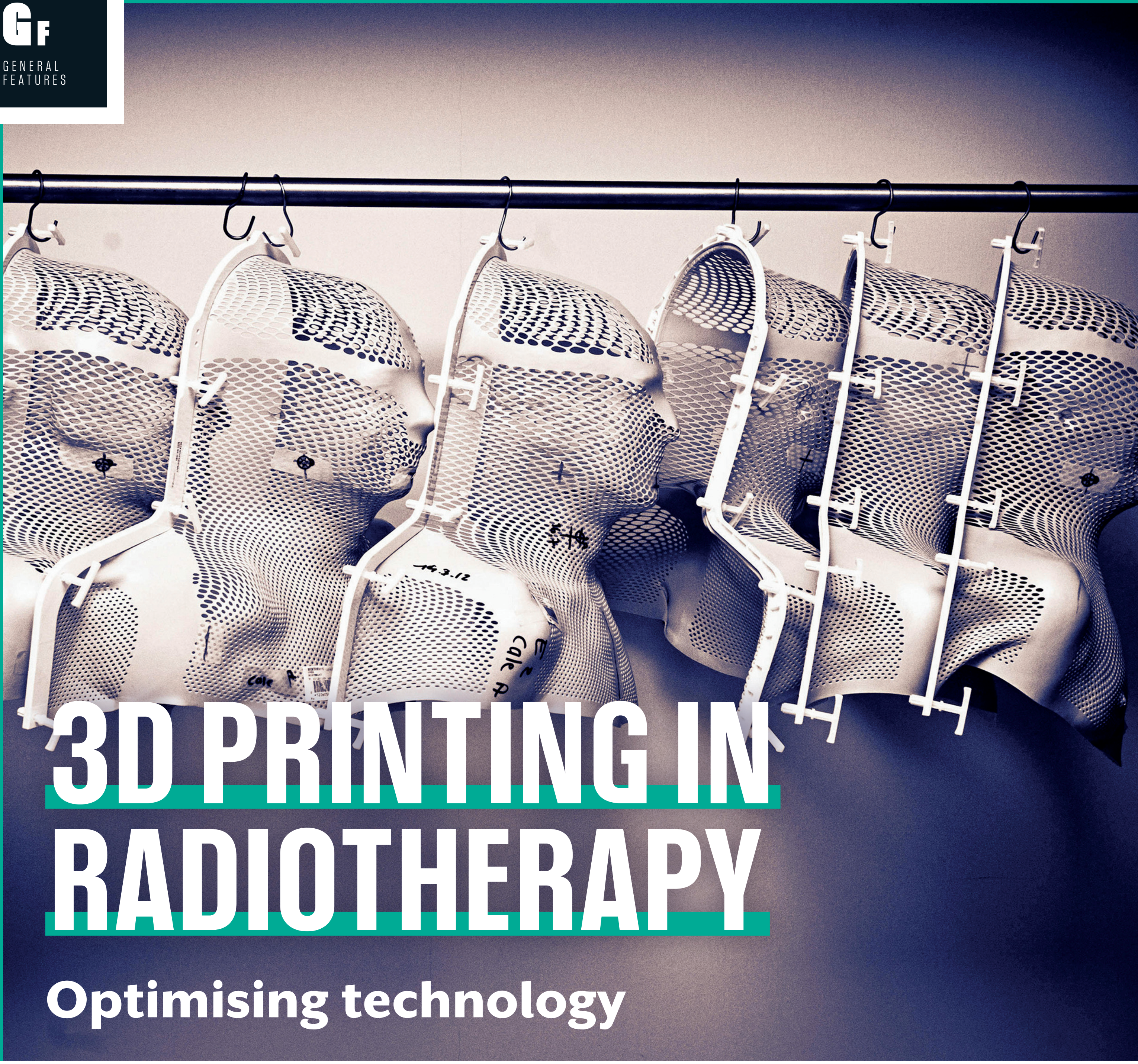
GENERAL FEATURES



3D PRINTING IN RADIOTHERAPY

Optimising technology

Luke Eason, a Clinical Scientist in Radiotherapy Physics at Leeds Cancer Centre, looks at the need for guidance on implementation, medical device directive compliance and risk assessment for 3D printing.

IMAGE: ALAMY

Three-dimensional (3D) printing involves the construction of a 3D object from a computer-designed model. Generic solutions, such as AutoCAD by Autodesk, allow the user to create a custom model using a variety of tools and processes. 3D surface scanners can scan objects and create a digital 3D model that can be edited. Specialised solutions, such as 3D Bolus and 3D Brachy by Adaptiiv Medical Technologies Inc, can be used to create models based on digital imaging and communications in medicine (DICOM) structure files and computed tomography (CT) images exported from a treatment planning system. In-house software solutions have also been developed, but caution must be taken regarding regulatory compliance requirements and ongoing support.

The 3D model must be converted into a format where the surface of the 3D model is mapped into a grid structure. This file format conversion is required so that the 3D model can be processed by a piece of software called a "slicer". This converts the file to G-code, a 3D printing programming language, that instructs the motors of the 3D printer where to move, how fast to move and what path to follow.

The slicer allows the user to select appropriate printing parameters, depending on the type of 3D printer used and the intended use. The most common types of 3D printer used in radiotherapy are:

- **Fused deposition modelling (FDM)**: a filament is melted and extruded from a nozzle onto a build plate. The 3D object is built up layer by layer. The G-code sets the path and speed of the nozzle. FDM is the most popular printing process due to its affordability, reliability and functionality.
- **Stereolithography (SLA)**: a vat of liquid resin is selectively cured using an ultra-violet laser layer by layer to form the 3D object. The G-code determines the laser path and speed. SLA printers offer a higher resolution print and quicker print times than FDM, but are significantly more expensive.

The most influential parameters on the dosimetric properties of the object are print material, infill density and print pattern. The print material will affect the density, rigidity, biocompatibility and tolerance of sterilisation of the object. The in-fill density is the percentage of the interior volume of the 3D model that is filled with material, where 0% is a hollow shell and 100% is a solid object. A lower infill shortens the printing time, but can compromise rigidity and will introduce air pockets within the object. The print pattern will affect the print duration, rigidity and homogeneity of the 3D object.

These parameters – and many more – affect the quality and dosimetric properties of the object and must be carefully evaluated.

The G-code – containing the surface mapping and all incorporated printing parameters required to build a 3D object – is transferred to the printer for printing. Printing can take many hours but often can be left unsupervised.

The current situation

The number of publications has risen dramatically in recent years as the technology has become more affordable, reliable and user-friendly. The most popular utilisation is bolus and brachytherapy applicator production demonstrating improved skin conformality and time efficiencies. The in-house manufacture of different types of phantoms, immobilisation devices, custom shielding and treatment verification phantoms and dosimetry jigs are also reported. This is not an exhaustive list and wide-ranging, cost-effective uses continue to be published.

These literature findings are insightful but scalable recommendations that could assist implementation in UK-based radiotherapy centres are needed. A 2023 UK and Republic of Ireland survey found that, despite the reported benefits and community interest, the clinical utilisation of 3D printing is not yet widespread nor standardised. A lack of guidance on implementation, compliance with the medical device directive and risk management were highlighted as barriers.

The IPEM 3D Printing in Radiotherapy Working Party, stemming from the wider IPEM Radiotherapy Special Interest Group, was established to assist in addressing these issues to increase uptake and optimisation of the technology and the benefits it can offer to patients and service efficiencies.

Good practice and addressing barriers

The working party organised a national conference at the National Physical Laboratory, London in May 2024. There were 76 delegates from across the UK and Europe with two expert guest speakers – Professors Tanya Kairn and Scott B Crowe from the Royal Brisbane and Women's Hospital, Australia, editors of the book *3D Printing in Radiation Therapy* (IOP Publishing, 2023).

There were a range of presentations and posters at the event, focusing on service development and patient experience. The scene was set by Prof Kairn and Prof Crowe with an overview of their established 3D printing service, with recommendations on implementation and optimisation. Their excitement and experience was apparent and of great use to all delegates.

Rhys Jenkins offered insight into introducing 3D printing to a radiotherapy physics service using SLA techniques. As SLA printers become more affordable, this experience is crucial in the wider adoption of this technology moving forwards. Jessica Woodward presented on using 3D printed bolus for head-and-

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AS SLA PRINTERS BECOME MORE AFFORDABLE, THIS EXPERIENCE IS CRUCIAL IN THE WIDER ADOPTION OF THIS TECHNOLOGY

IMAGE: NOUN PROJECT

Figure ❶ A visualisation of the range of experience brought to the conference by delegates.

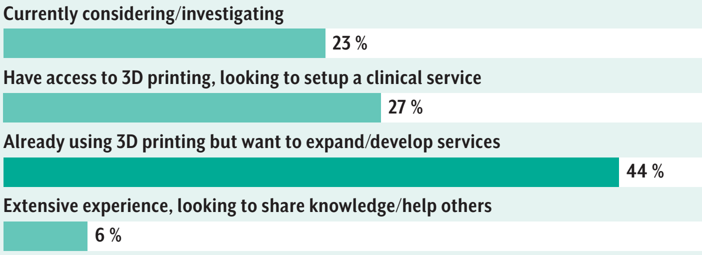
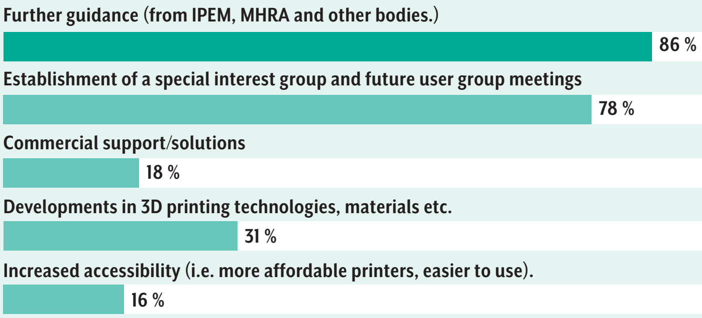


Figure ❷ A poll of delegates indicating what needs to be done to further development 3D printing in radiotherapy.



neck patients and how it has replaced conventional techniques. This was supported by an audit of 10 patients that demonstrated improved accuracy and the potential for reduced skin toxicity. Tim Hosking similarly presented on how 3D printed bolus can be used over and under head shells in head-and-neck radiotherapy. Meagen de la Bastide demonstrated a Raystation-specific solution to the creation of silicone bolus from 3D-printed casts. Francis Lavender called attention to 3D printed shielding and bolus for skin cancer treatment using electron radiotherapy. Susan Bartley highlighted the patient and staff experience of using 3D printed methods in their talk, where the comfort of the printed bolus and ease of production were discussed. John Mills reflected on experience with the production of 3D printed casts for low-melting-point alloy masks, highlighting cost-effectiveness and more comfortable shielding for patients to wear. Their second presentation of the day focused on the design and production of a chest wall bolus print, highlighting problems and solutions found. Ahmar Yaseen and Amani Chowdhury presented their experience with 3D printing in skin brachytherapy, demonstrating the ability to produce better fitting applicators than conventional techniques with a reduced set up time.

Britt Haanen presented on using 3D printed accessories for use in gynaecological brachytherapy, with a focus on sterilisation techniques and clinical implementation. Roua Abdulrahim and Matt Jones each presented their work on designing and creating customised phantoms for use in radiotherapy treatment development and verification, highlighting the benefits of producing truly bespoke equipment for the benefit of service delivery. Between presentations, there were two interactive sessions that allowed for more open discussion. Delegates highlighted high-quality, topic relevance, networking opportunities and enthusiasm and 95% said the conference met or exceeded expectations. The most common reasons for attendance were professional development (95.5%) and networking (50%).

Throughout the day, Slido, an online Q&A and polling platform, allowed delegates to submit questions and vote on polls to gauge audience experience and focus discussions appropriately. The most common questions centred around hardware and software use, appropriate 3D printing materials and printing parameter selection.

Figure ❶ shows the range of experience of delegates who attended the event. Of the 44% of delegates with experience, 62% was in bolus design/fabrication. While 58% of delegates said the lack of guidance was the biggest challenge, and this was reflected in the range of answers raised regarding printing materials, quality control/assurance processes, quality management system implementation, hardware/software use, staff allocation and the location of the 3D printer(s).

Figure ❷ is a poll of delegates highlighting what is needed to help develop 3D printing in radiotherapy.

On personal reflection, this was a fantastic networking opportunity and covered a wide range of topics that will be useful when implementing this technology at my centre in 2025. The presentations and posters were of excellent quality and very helpful to me as an early-career researcher in this area. Many thanks to IPEM for providing part-funding to attend this conference.

What's next?

A total of 38% of delegates indicated they were awaiting publication of guidance, and the IPEM topical report: guidance on 3D printing in radiotherapy has been accepted for publication to assist centres in the implementation of this technology. This will complement the existing generic guidance currently available. Further documentation is also expected from European and US organisations in the future.

A user group to assist in networking opportunities will help services further optimise and develop 3D printing to the benefit of patients and radiotherapy services. This is a truly exciting time to be involved in this active area of research, with interesting new developments expected this year and beyond.

IN MEMORY OF: ROSA MARIA SANCHEZ PANCHUELO

We are deeply saddened by the loss of Dr Rosa Maria Sanchez Panchuelo, a valued Clinical Scientist in the MRI Physics team at University Hospitals Birmingham (UHB) NHS Foundation Trust. Rosa passed away in February 2025 after a brave battle with cancer, leaving behind a valuable legacy in MRI physics and clinical service.

Rosa began her MRI career at the Sir Peter Mansfield Imaging Centre (SPMIC), University of Nottingham, where she undertook her PhD in 2006 on high resolution anatomical and functional imaging. She worked at the SPMIC for over 15 years, becoming a leading researcher in ultra-high-field 7T MRI. Her pioneering work revealed detailed insights into the functional and structural organisation of the somatosensory and visual cortices. Among her most influential publications were "Mapping human somatosensory cortex in individual subjects with 7T functional MRI" in 2010 and "Within-digit functional parcellation of Brodmann areas…" in 2012, both of which set a high bar for precision in brain imaging.

In 2021, Rosa joined the clinical MRI Physics team at UHB. Despite being diagnosed with stage 4 cancer shortly afterwards, she made exceptional contributions to the department and wider clinical practice. Her dedication, resilience and kindness inspired everyone she worked with. She supported clinical teams across many hospitals, always going the extra mile to improve services with positivity and care.

A particularly impactful part of Rosa's recent work was her involvement in IPEM's MR Advanced Acceleration Technology (AAT) Task and Finish Group. She championed the implementation of AAT across the West Midlands, leading to substantial scan time reductions –up to 50% in some cases – without compromising diagnostic quality. Her collaborative approach brought together radiographers and radiologists to deliver improvements in workflow and patient experience. Rosa also participated in IPEM's Task and Finish Group on MRI Protocol Development Standardisation and Sharing, contributing until shortly before her death.

Rosa led the analysis and write-up of a major study evaluating the test-retest reliability of the "Home Town Walk" fMRI paradigm, used in pre-surgical assessments of memory function in epilepsy patients. Published in *Frontiers in Neurology* in 2024, the study demonstrated the robustness of this clinical tool and exemplified Rosa's commitment to research that directly benefits patient care.

Colleagues remember Rosa as a dedicated scientist who brought energy, enthusiasm and kindness to every interaction. "Rosa was an incredible person with great energy and enthusiasm and will be deeply missed by all who knew her," one colleague shared. Another reflected: "I was so impressed by her openness, kindness and lovely nature, as well as her ability to engage and inspire in MR physics." Despite her illness, Rosa remained a constant source of support and optimism, leaving a lasting impression on all who worked with her.

Rosa brought the same passion to her personal life and was a devoted partner and mother. She had a strong competitive spirit, a lifelong love of sport and especially enjoyed climbing, hiking and exploring new places with her family. She was proud of her Spanish heritage and loved recreating traditional dishes from her childhood, blending Spanish and French traditions.

Rosa will be remembered not only for her scientific achievements but also for her warmth, integrity and the inspiration she offered to those around her. Her legacy will continue on in the lives and work of the many people she influenced.

NUCLEAR MEDICINE TECHNOLOGY

Exhibit equipment review

Roger Staff, Head of Department Clinical Physics Imaging Team at NHS Grampian, gives with an overview of some of the equipment on show at the European Association of Nuclear Medicine congress.

The flagship event in the Nuclear Medicine Calendar, renowned for advancing global medical innovation, occurred in Hamburg, Germany last October, with over 7500 participants from 77 countries and 150 companies exhibiting. The European Association of Nuclear Medicine (EANM) annual congress was of its usual high standards, with AI and therapies being particularly hot topics.

Aside from the science, EANM's concerns about future workforce shortages were repetitively highlighted. We are all aware of workforce difficulties and jeopardising care and this will worsen, with 21% of the workforce expected to retire within five years. To address the coming crisis, EANM have formed the Young Professional Council to empower and involve the next generation of nuclear medicine professionals and developed the INSPIRE initiative to tackle these challenges. Complimentary to this, and in keeping with the German theme, the option of "Vorsprung

durch technik" (progress through technology) seems more pertinent today than ever. Doing more with less is an essential direction of travel for the discipline.

The exhibition

As is customary, the EANM annual meeting was accompanied by a grand equipment exhibition featuring product launches, bold claims and razzamatazz. Among these, GE's Aurora SPECT/CT shone brightly. The technological advancements, such as a high-end computed tomography (CT) and the introduction of its CLARIFY DL AI reconstruction, have ignited a sense of optimism. Bruno Vanderlinden, a Radiation Physicist at Brussels University Hospital, has hailed it as the "Swiss army knife of imaging machines" – a testament to its potential. The future operational gains of this versatile system are yet to be fully realised, much like the many features of a Swiss army knife that are often undiscovered or not exploited. Siemens highlighted its Symbia Pro.specta SPECT/CT scanner theragnostic edition. Launched two years ago it comes with high-end CT imaging functionalities, automated SPECT motion correction management, and their myExam Companion. A package of tools aimed at streamlining the scanning process, although the clear operational gains are yet to be revealed to the community in many settings. It remains unclear to me which market needs a state-of-the-art SPECT system and a high-end CT combination. We all like better kit. A one-stop shop for cardiology MPI, CTCA and Ca scoring, perhaps?

PET and CT sector

The positron emission tomography (PET) CT sector has been the most interesting. With the demand for PET increasing, the operational need has been for faster throughput machines. In the research space, total body PET is available and invested in by prominent research institutions, although its cost makes it non-viable in most operational health settings. In addition, the proven clinical and operational gains are yet to be demonstrated. However, the clear trend towards a larger field of view for PET is a promising development that excites us about the future of PET/CT technology and its possibilities. This development not only inspires but also excites us all about the future of PET/CT technology and the opportunities it opens up.

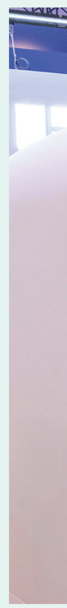
Field-of-view market

The larger field-of-view (FoV) market is becoming increasingly competitive. GE OMNI Legend, a pioneer in this market, has been joined by Siemens Biograph Trinion and United Imaging's (UI) uMI Panorama. While Siemens and GE have established a presence in the UK, UI is new and intends to enter the market.

The GE OMNI-Legend system is established in the UK. The system has dBGO small crystal size and a 32cm FoV. However, it does not have time-of-flight (ToF) functionality. Instead, it uses GE Healthcare's Precision DL (deep learning) capabilities to provide contrast and resolution comparable to conventional ToF systems. The Siemens Biograph Trinion, launched this year as the next iteration of their successful Biograph series, uses a more conventional ToF approach with a respectable 239 ps capacity and small LSO crystals. The system comes with an 18 or 24-cm FoV. The uMI Panorama is United Imaging's competitor to these two systems, boasting a 189 ps ToF capability and a 28 or 35-cm FoV.

The operational desire to increase throughput is primarily driven by sensitivity. A larger FoV means more counts, allowing a reduction in acquisition time. The Trinion, OMNI, and uMI 46, and 21 cps/kBq, respectively. However, a direct comparison of the resulting image quality for a given acquisition time is difficult due to reconstruction and post-processing approaches. The 1cm (NEMA) axial resolution is quoted as 4.2, 2.5, and 2.9 mm for the Trinion, OMNI, and uMI Panorama – these raw numbers again do not obviously translate into marked differences in operational quality.

Alternatives for addressing the capacity are to produce better images with fewer photons. The recently launched Siemens Biograph Vision X boasts a ToF of 178 ps and 26 cm FoV. The new detector and an upgrade in the underlying electronics within the detector bring about these gains. Combined



with their AllPass filter-less ToF reconstruction approach, it represents a bold offering.

Air-cooled PET and AI

A developing trend is the introduction of air-cooled PET systems. There is no requirement for troublesome chillers, freeing up location choice and potentially improving reliability. Who has not had chiller problems? UI has the uMI Panvivo and the Siemen Trinion, which both have competitive characteristics and modest footprints. Both these models are expected to reduce installation challenges.

With future acquisition time expected to be < 10 minutes, ease of set-up is becoming an increasingly significant proportion of the appointment slot. UI and GE have introduced AI tools and an overhead camera to aid patient positioning and acquisition set-up. Feedback from early adopters has been positive. “The AI positioning tool contributes to a quicker patient turnover and enhances efficiency and improves patient safety,” said Bettina Ferre, Senior Technologist UCL London. Siemens provides an accelerated set-up approach based on an initial CT topogram and an AI version of their established FlowMotion approach.

Cloud based

With the relentless march and improvement of PACS-based reporting, multi-modality reporting on the likes of Carestream or Sectra is possible. With the quantification, registration, dosimetry, and parametric mapping necessities, PACS-based reporting generally does not meet all modern requirements. The conventional solution in molecular imaging is a separate software platform supplied (or not) by the PET or SPECT system supplier.

All the vendors provide software packages to meet almost all needs with little differentiation between them. We all have our favourites, probably influenced by what we were trained using. The brave new world of cloud-based execution of such tasks can be challenging to achieve with risk-averse NHS IT and information governance oversight. We are left with the option of “buying a box” to sit inside the firewall solutions. This does not future-proof you, restrict distribution, limit CPU/GPU power access, or move to a pay-for-what-you-use model.

GE Healthcare recently acquired MIM Software Inc, so its platform and functionality are expected to progress and expand. They have recently obtained FDA clearance for a new centiloid scaling tool to quantify amyloid plaque in PET brain imaging, putting it on par with other vendors. However, the value of such tools in a world without an accessible and robust therapy remains unclear. Vendors such as Siemens and HERMES provide a robust suite of applications, and all vendors offer thin client and cloud-based options. New to the market is OMNIspace by UI, which satisfies all conventional needs and has integrated INVIA’s Corridor4DM product into the AI-powered advanced visualisation workspace. One of the many AI tools on the show was the UI Discovery PET/CT abnormal tool. It was similar in functionality to other vendors, with what appeared to be an effortless and comprehensive report generation and text population step. We are far from complete AI reporting in PET with no human involvement; however, this partial report generation can potentially improve throughput by faster reporting and, thus, capacity.

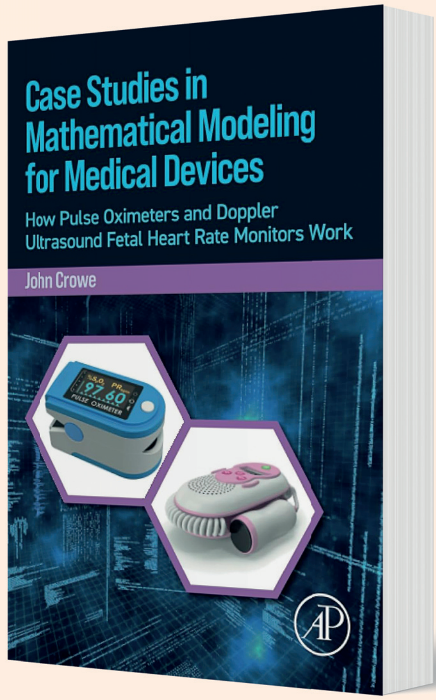
Doing more with less

The meeting was broadly successful, with vendors and large nuclear medicine departments presenting their cutting-edge products and research. Most of us will probably not see such advances anytime soon, with the life cycle of pieces of equipment exceeding 10 years. Given the pace of change, waiting a decade for an equipment refresh will leave smaller services behind. The emphasis on doing more with less looks here to stay. This may lead to a concentration of equipment and expertise, enabling capital assets to be squeezed away from more distributed services.

BOOK PITCH

Case Studies in Mathematical Modeling for Medical Devices

John Crowe outlines the ideas and the content within his new book on pulse oximeters and doppler ultrasound fetal heart rate monitors.



My 40+ year career has included working on the design, construction and testing of numerous medical devices and methods. This includes various fetal heart rate (FHR) monitors, intrapartum assessment using mass spectrometry, the heart rate monitoring of newborns using photoplethysmography, laser Doppler based microcirculation imaging, a capillary refill monitor and a retinal oximeter.

The operation of these devices involves the collection of data from the body using some form of transducer, the processing of this data to extract the required information and the display of this information in an appropriate manner. What is valuable in the design of any such device or method is if their operation can be modelled, since an in-depth understanding of their operation should enable them to be optimised.

The motivation for this book was to demonstrate this principle using two case studies: oximeters and doppler ultrasound based FHR monitors. The source material was the documentation of the information describing their operation in various papers and reports we have written and, of course, numerous PhD theses.

In the case of conventional pulse oximetry (CPO) there have been multiple reviews of the subject with most taking the "standard" approach. This is often overcomplicated in the way that the background attenuation of tissue is dealt with, yet oversimplified in its application of the (linear) Lambert-Beer law. Here the explanation is from first principles with an emphasis on the non-linear relationship between attenuation and absorption governed by the temporal point spread function's (TPSF) cumulants.

It includes a brief review of how the theory can be applied to multiple types of oximeter.

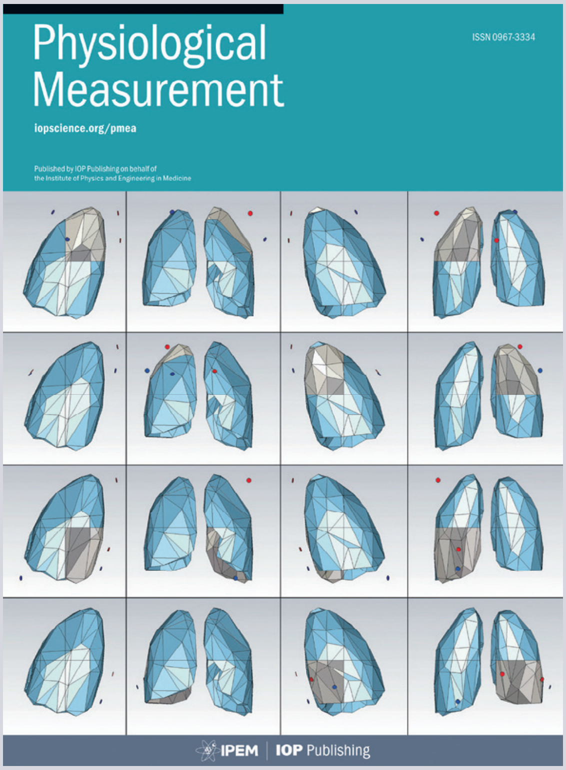
Other content includes a simplified explanation of how the Masimo corporation's oximeters operate compared to CPO and a suggestion, supported by modelling, that the accuracy of oximeters at high saturations may be partly due to the wavelengths chosen in the first instance to ensure oximeters have the required sensitivity.

The second case study is of FHR monitoring using doppler ultrasound. The operation is modelled from the insonating ultrasound through the receipt of the doppler shifted signal to its processing and use to monitor FHR. In addition to modelling the usual operation, the use of band-pass sampling to simplify the processing required is also considered.

Whist the book hopefully proves of value to anyone who wishes to understand how these two devices operate; and may inspire the development of more accurate or efficient monitors, another aim was to act as an applied maths text. In this role students would see how statistics can be applied to model the random scattering and absorption of light that takes place in oximetry, and how Fourier-based signal processing can be used to model the signal pathway in FHR Doppler ultrasound based monitors.

> "IT INCLUDES A REVIEW OF HOW THE THEORY CAN BE APPLIED TO MULTIPLE OXIMETERS

Case Studies in Mathematical Modeling for Medical Devices: How Pulse Oximeters and Doppler Ultrasound Fetal Heart Rate Monitors Work *is published by Academic Press – an imprint of Elsevier. For more information visit* ***b.link/v1vdfrck***



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