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IPEM
Institute of Physics and Engineering in Medicine

Volume 33 | Issue 04 | Winter 2023

SCOPE

RISE OF THE ROBOTS?

Investigating AI in medical physics and clinical engineering

THE BIG DEBATE

Rejoining Horizon Europe – the research and innovation programme

AWARD-WINNING ESSAY

The future role of physics in the fight against cancer

SURVEY

Methods and approaches to patient dose audits

BOOK PITCH

Bioinformatics and clinical scientific computing

RAD formation

Intelligent Automation in Cancer Care

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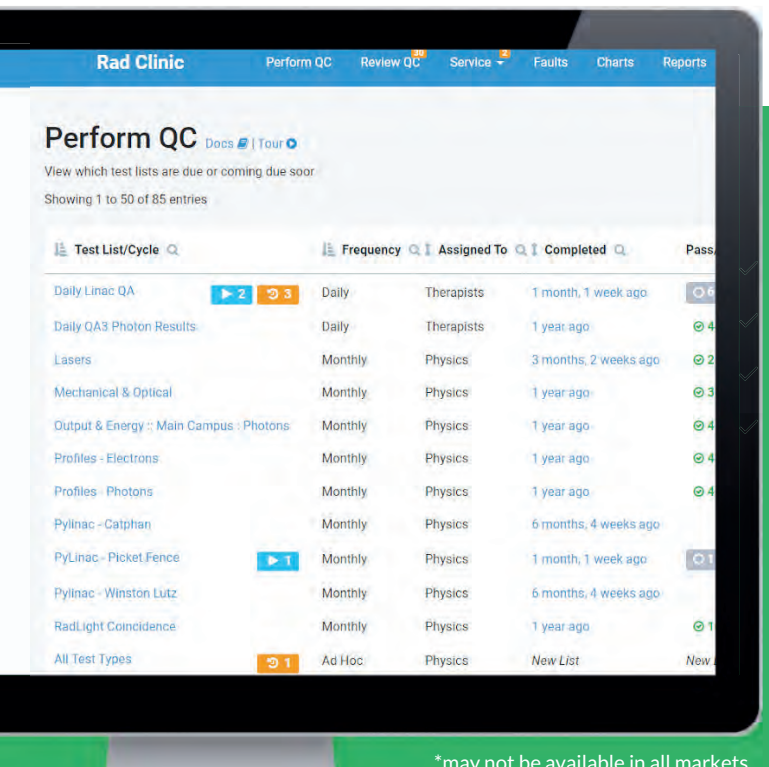

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Fantastic features

Usman Lula outlines the content in the latest issue, including an in-depth look at Horizon Europe and an award-winning essay.

Congratulations to Anna Barnes on becoming IPEM's first female President

Welcome all to the final *Scope* issue of 2023! I'd like to start by thanking all the authors for their wonderful contributions to the magazine. We've had some fantastic features submitted this year and we plan to bring you even more in 2024. Keep your eyes peeled.

In this issue our "Big Debate" section is on rejoining Horizon Europe – the key funding programme (with a budget of €95.5bn between 2021–2027) for research and innovation in Europe – and its impact on medical physics and clinical engineering services. We have six panel experts who have kindly contributed to this interesting piece, so look no further and turn to page 14 for more.

Recently, I happened to hear about one of our very own *Scope* magazine Commissioning Board members, Helen Chamberlain, winning the IPEM Early Career Essay Prize in 2023 for her piece on how the role of physics in the fight against cancer will develop over the next 10 years. This was highlighted on the news portal on the IPEM website and I found the essay really valuable – the key aspect was how it highlighted and connected numerous applications to physics and perhaps something that could be used by prospective students. A fantastic essay and a must read (see page 30).

You may be aware that there was an IPEM Science Leadership event in York on 29 September 2023 that explored the future of medical physics and clinical engineering. As a volunteer for IPEM, I found this event helpful in learning to develop robust strategies that pass the test of time and this really was a new experience for me. The day was run by SAMI Consulting – an organisation of experts in futures thinking and strategic foresight – and it helped generate lots of useful ideas around IPEM's *Science Leadership Strategy*, which complements IPEM's 2025 strategy (see page 48).

For those wanting to get their teeth into learning more around bioinformatics and clinical scientific computing – Paul Ganney has written about his new book in this very issue on page 54.

Finally, very many congratulations to Anna Barnes on becoming IPEM's first female President.

Enjoy the read. Wishing you all a healthy and prosperous new year.

Usman Lula

Usman Lula
Chair of IPEM Scope EAB

A NEW SERIES

Artificial intelligence: a primer

Several months ago, the *Scope* Editorial Board was discussing what to include in the magazine that is contemporary and interesting. Soon after, Catriona Inverarity, who was Professional Knowledge and Innovation Manager at IPEM at the time, sent out an email with an idea from the newly established IPEM AI group and the Nuclear Medicine Special Interest Group that we should review the current status and future opportunities of AI. To kick start this, we have our first instalment of an AI series with a primer kindly provided by Robert Ross, Clinical Computing Lead at Cheltenham General Hospital. On page 22 he provides the low-down on the definition of AI, benefits in healthcare, data curation, bias, ethics, risks and regulations.

IPEM
Institute of Physics and Engineering in Medicine

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CO

THE BIG DEBATE

14/ HORIZON EUROPE

We ask a panel of experts eight questions about rejoining the EU's key funding programme for research and innovation, Horizon Europe. They discuss the implications for medical physics and clinical engineering and cover issues ranging from the specific advantages and opportunities gained by rejoining to how the move will affect funding, collaboration and competitiveness for universities and institutions

> UK government seems to have found a good balance between traditional subjects and innovative, cutting-edge research, but has a long way to go to establish productive public-industry partnerships.
>
> ***Professor Magdalena Stoeva***
> *Secretary General, International Union for Physical and Engineering Sciences in Medicine* **page 14**

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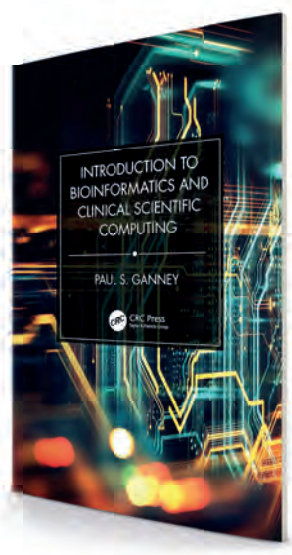
GENERAL

ENDNOTES



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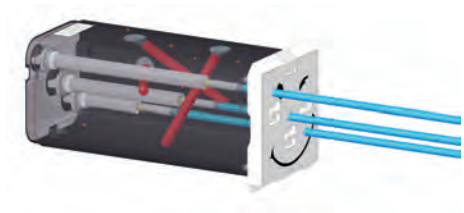

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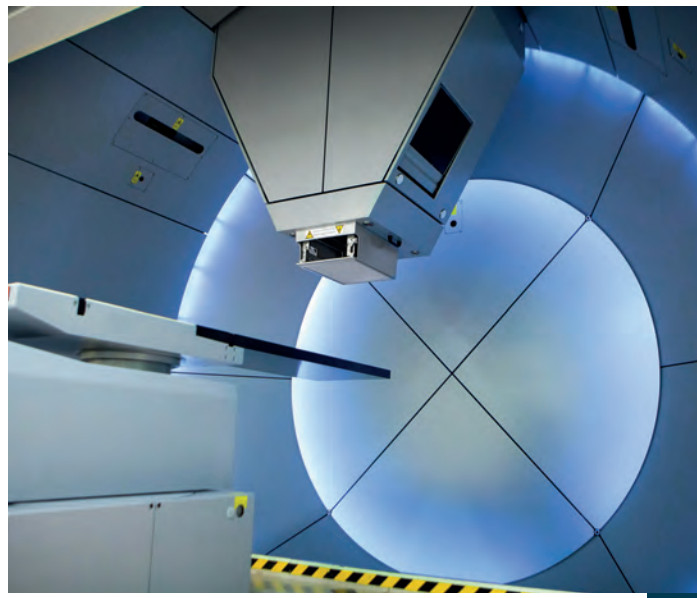
UPFRONT



PROTON BEAM THERAPY

Transforming cancer treatment

Cancer treatment could be transformed following a breakthrough in the development of a new and highly accurate radiotherapy treatment.

Scientists at the National Physical Laboratory (NPL), led by IPEM Fellow Russell Thomas, Science Area Leader of Medical Radiation Science, have worked on a range of projects that are set to significantly improve the accuracy of proton beam therapy (PBT).

They are also working with IPEM to develop a new Code of Practice (CoP) for reference dosimetry of proton beams.

PBT is seen as a superior option to established radiotherapy as the radiation can be confined largely to the tumour, minimising the damage to surrounding healthy tissue. To make the most of the treatment, however, the accuracy of the radiation dose from proton beam treatment must be similar to that achieved using existing radiotherapy treatments.

To achieve this aim, the team at NPL has made three important breakthroughs:

- Producing a highly accurate tool for measurement and assuring radiation dosage amounts called the Primary Standard Proton Calorimeter (PSPC)
- Developing new tissue-equivalent plastic materials to precisely imitate human tissue, such as bone and muscle, at the test phase
- Performing pioneering measurements to demonstrate a new form of radiotherapy – FLASH.

To maximise accuracy and consistency of radiation dose measurement in PBT, the NPL developed the PSPC to directly measure the absorbed radiation dose in proton radiotherapy beams.

Radiation dose measurement always comes with a level of uncertainty, but NPL's PSPC reduces this uncertainty by more than half (0.9% instead of 2.%), as reported by the international CoP for radiotherapy dosimetry (TRS-398), making it more accurate than current international protocols.

With the PSPC, NPL ensures cancer patients undergoing PBT receive consistent and accurate radiation doses across different treatment facilities. This improves the chances of successfully treating the tumour and reduces variability in dose delivery to patients.

The NPL team has also developed pioneering new plastic materials that mimic the radiation properties of human bone and muscle tissue for photon imaging and proton beam treatments.

Existing test materials produce large uncertainties in proton therapy dosimetry resulting in relative differences in "range" of up to 8%. As such, these existing materials cannot be used to provide accurate quality assurance measurements for proton therapy dosimetry.

In contrast, the new materials developed by NPL closely mimic the properties of human tissue in a proton beam within a one-to-two percent accuracy: this makes them much more effective when used to support radiation dosimetry measurements for complex proton treatment plans and clinical trials.

bit.ly/3FRgdSm

IMAGE: ALAMY/ISTOCK/SHUTTERSTOCK

FAST FACTS

>50%
NPL's PSPC reduces uncertainty by more than half (0.9% instead of 2.3%).

8%
Existing test materials produce uncertainties in dosimetry resulting in relative differences in "range" of up to 8%.

6 WEEKS
Delivery period for conventional radiotherapy.

NEW HOSPITALS PROGRAMME

"DEDICATED SPACES NEEDED"

Spaces for medical physics and clinical engineering staff needs to be included in new hospital buildings, a meeting was told.

Representatives from IPEM took part in a New Hospitals Programme workshop, looking at how new hospitals should be designed in terms of effective care pathways and patient throughput efficiency.

The programme was announced by the government three years ago, with the aim of building 40 new hospitals by 2030. However, the National Audit Office report on progress on the programme earlier this year said the government will not deliver these hospitals within that timescale.

Jen Cannon, IPEM's new Professional Knowledge and Innovation Manager, said: "We highlighted that none of the plans included dedicated space for medical physics or clinical engineering, and that having space for our staff to collaborate with radiology colleagues was an extremely important factor to be considered in new hospital design."

bit.ly/3stxGgM

LEADERSHIP

First female President of IPEM

Dr Anna Barnes, an IPEM Fellow, became the Institute's first female President after her appointment was confirmed at the Annual General Meeting.

Dr Barnes said: "My aim is not to be the first and only female President this decade and I feel really privileged to take on this role at this exciting time for IPEM.

"I'm really looking forward to my presidency and to pushing forward on important matters, such as equity of opportunity, diversity of thinking and inclusion across academia, industry and public healthcare.

"I have stepped into this role because I felt the time had come that a woman needed to step into a leadership position so that almost half of our members can see that they can also do this job.

"You can't be what you can't see, and I want to say to my male colleagues you are part of this journey and you are our allies.'

A Clinical Scientist in the School of Biomedical Engineering and Imaging Sciences at King's College London, and a Director of the King's Technology Evaluation Centre at KCL, Dr Barnes has been involved with IPEM throughout her career.

She was one of the first two IPEM trainees in Scotland in 1993, specialising in biomedical engineering and equipment management.

Dr Robert Farley, who is now Immediate Past President of IPEM, said: "I am delighted Anna is our new President. She has many exciting ideas for taking both IPEM and the medical physics and clinical engineering professions forward.

"I wholeheartedly support her aim to build on the equity, diversity and inclusion work done by IPEM and to make it sustainable for the foreseeable future."

bit.ly/3sC5g49

OBITUARY

ALISTAIR MURRAY OBE

Alistair Murray, former Head of the Department of Medical Physics and Bioengineering at Raigmore Hospital, Inverness died in May this year aged 88.

Alistair was a Highlander through and through having been born and brought up in the far north of Scotland. His Christian faith was an integral part of his life. He was kind and compassionate with a great sense of humour, but nevertheless he had a steely ambition.

He studied Physics at Edinburgh University with a view to a career in medical physics. After university he took up a post in the Medical Physics Department at Dundee. He followed that with posts at Mount Vernon Hospital, Aberdeen and the Queen Elizabeth Hospital in Birmingham before eventually returning to the Highlands and Inverness where he set about starting the

REPRESENTATION

Global Clinical Engineering Alliance

IPEM has joined an international organisation representing the clinical engineering field worldwide.

The Global Clinical Engineering Alliance (GCEA) empowers and recognises the clinical engineering profession for its unique contribution to improving healthcare delivery outcomes.

It helps to address shared healthcare challenges and provides international professional networking between and across healthcare stakeholders, associations, policy makers, global agencies, academia, government and industry.

The GCEA's goal is to educate and advocate via global alliances for patients and staff and supports the expansion of education programmes designed to improve systems thinking, standards and regulatory frameworks.

IPEM has now joined 14 other organisations around the world who make up the GCEA, which was formed after the Global Clinical Engineering Day in 2020.

bit.ly/479ycj6

department at Raigmore Hospital.

He recruited Alan Bowley, who had a wealth of engineering experience, as his Deputy and the department grew from those small beginnings supporting radiotherapy, nuclear medicine, ultrasound and radiation protection and diagnostic radiology (serving both the Highlands and the Western Isles).

In later years, the department expanded to include Rehabilitation Engineering so that by the time Alistair retired in 1995 the staff numbered some 60 people.

I had the privilege of working in the department in Inverness in the seventies and early eighties. It was a time I greatly enjoyed, not least because it was a very happy department and Alistair and Alan both had great senses of humour.

Alistair could be thought of as one who brought medical physics to the Highlands, but he remained humble and unassuming and is greatly missed by family and friends.

Karen Goldstone

NEWS IN BRIEF

Organ motion

A novel radiation therapy technique has been devised to predict the three-dimensional motion of each organ based on its position with respect to the surrounding organs. This was achieved by acquiring cross-sectional (two-dimensional) images from three different orientations of the affected area in real time during radiation therapy. Additionally, a cross-section selection method was formulated to choose the most accurate cross-sectional image for analysis.

bit.ly/47gttvyd

Novel ECG patch

A group of researchers from Australia and India have presented a novel wearable electrocardiogram (ECG) patch for enhanced point-of-care diagnostics. Typically, "wet" electrodes, are used in devices to measure ECG signals and include a conductive gel to enhance electrical signalling. The new study focused on the advantages of using active dry electrodes. The team created a compact, lightweight, gel-free hexagonal-shaped ECG patch ideally suited for point-of-care diagnostics. The configuration was then integrated with Bluetooth communication for remote sensing capabilities.

bit.ly/3u4gXRt

Portable plasmonic biosensor

A new study demonstrates the first application of fibre surface plasmon resonance (SPR) technology in the sensing of SARS-CoV-2 virus in environmental samples. The proposed fibre probe is virus-specific with the limit of detection of ~2300 copies/mL, and copy numbers of viral genome can be reflected as shifts in wavelengths. A series of sewage water samples from different sources have been examined by fibre SPR, and the data obtained from biosensor are consistent with those of quantitative polymerase chain reaction (qPCR) and colorimetric assays.

bit.ly/40rIpoE

HONORARY FELLOW

Professor Heidi Probst

A leading researcher into radiotherapy for patients diagnosed with breast cancer has been made an Honorary Fellow of IPEM.

Professor Heidi Probst has just stepped down as Director of the Health Research Institute at Sheffield Hallam University, where her research is currently looking at ways to improve the accuracy and reproducibility of breast irradiation whilst ensuring the patient experience is as positive as possible.

Professor Probst started her PhD while working as a clinical radiographer at Leeds Teaching Hospitals NHS Trust and was awarded a fellowship by the Department of Health to complete it. This was a randomised clinical trial investigating different radiotherapy protocols for patients treated for breast cancer.

She joined Sheffield Hallam University after completing her PhD and has spent the last 20 years teaching radiotherapy and oncology at both undergraduate and postgraduate level.

bit.ly/40yFUkn

CHECKLIST PUBLISHED

ULTRASOUND EQUIPMENT

A new checklist for pre-owned ultrasound equipment has been published.

A collaboration between AXREM, the UK trade association representing the interests of suppliers of diagnostic medical imaging, radiotherapy, healthcare IT and care equipment, IPEM, the British Medical Ultrasound Society and the Society of Radiographers, has produced the Pre-owned Equipment Checklist for Ultrasound.

The document consists of three checklists, the first of which refers to ultrasound probes – the most common point of failure which are replaceable without any changes to the ultrasound system. The checklist is free to download.

bit.ly/3Qjt7gX

NEWS IN BRIEF

Microscopy resolution breakthrough

Obtaining high-resolution images in the world of microscopy has long been a challenge. Deconvolution, a method to enhance image clarity, often amplifies noise between the sample and the image. Researchers at Boston University recently developed a novel deblurring algorithm that avoids these issues, improving the resolution of images with photon intensity conservation and local linearity. The algorithm is adaptable to various fluorescence microscopes, requiring minimal assumptions about the emission point spread function (PSF). It works on both a sequence of raw images and even a single image, enabling temporal analysis of fluctuating fluorophore statistics. Furthermore, they have made this algorithm available as a MATLAB function, making it widely accessible.

bit.ly/49ag89U

Tumour-destroying soundwaves

The US Food and Drug Administration has approved the use of sound waves to break down tumours – a technique called histotripsy – in humans for liver treatment.

Pioneered at the University of Michigan, histotripsy offers a promising alternative to current cancer treatments.

Histotripsy works by using targeted ultrasound waves to form microbubbles within the tumour. The forces created as those bubbles form and collapse cause the mass to break apart, killing tumours cells and leaving the debris to be cleaned up by the immune system.

A human trial, underway since 2021 at the U-M Rogel Cancer Center and other locations, has treated patients with primary and metastatic liver tumours via histotripsy, demonstrating the technology's ability to meet the testing's primary effectiveness and safety targets.

While earlier this year, a cancer patient from West Yorkshire has become the first person in the UK to have a kidney tumour removed using sonic beams at Leeds Cancer Centre.

bit.ly/3tX8rDW

A CLARIFICATION

Quality assurance and interdepartmental audits

Recent timely summaries of the history of radiotherapy trials quality assurance and the beginnings of interdepartmental audit in *Scope* magazine ("History of Radiotherapy Trials Quality Assurance" by Dr Edwin Aird and "The Beginnings of Interdepartmental Audit (Part 2)" by Prof David Thwaites) have provided current users of quality systems and medical physicists involved in clinical trials with a clear overview of their development from the first audits. However, I feel that clarification of some events would be helpful.

Regarding the first audits, these only started after a 1987 biannual meeting of the Scottish Radiotherapy Physicists Group with the Common Services Agency of the Scottish Home and Health Department, which I attended. Here, travelling expenses, for which the group pressed for the funding of a Scottish dosimetry intercomparison, were granted.

This funding facilitated the completion of the interdepartmental audit in Scotland, so bedded in a UK process for further regional audits in England. While there was no central grant funding for these, travelling expenses were often funded regionally and time spent on such audits was seen as an exchange of hours between departments.
As described in these articles, this interdepartmental audit led to the 25% photon dosimetry discrepancy being found at Exeter in July 1988.

However, regarding the subsequent audits of electron dosimetry and planned deliveries of treatments, these started significantly earlier than reported in the "The Beginnings of Interdepartmental Audit (Part 2)". In a quality audit led from Oxford in 1993, 10 departments were comprehensively audited: this included electron dosimetry and treatment planning (which identified, for correction before clinical use, a 15% dosimetry discrepancy on a new linac); photon dosimetry and (both isocentric and fixed fsd) treatment planning; and documented procedures (for megavoltage units and treatment planning systems). A further three less comprehensive audits were also undertaken at Coventry, Bristol and the Royal Marsden, Sutton.

Dr Henry Weatherburn
(Independent) Consultant Medical Physicist/ MPE

IMAGES: SCIENCE PHOTO LIBRARY/ALAMY/ISTOCK/GETTY

MPE CERTIFICATION

ASSESSMENT OF PORTFOLIOS

Concerns about the assessment of Medical Physics Expert (MPE) portfolios taking a long time to be assessed have been raised by IPEM.

Phil Morgan, IPEM's Chief Executive Officer, recently met with the RPA2000 Board to discuss how the Institute can help and support to ensure MPE portfolios are assessed in a timely manner.

The meeting came after a number of members raised concerns over the significant periods of time being taken by RPA2000 to carry out the assessment.

RPA2000 assured IPEM they are addressing these concerns and are considering a number of ways to streamline the process and have published a statement on their website.

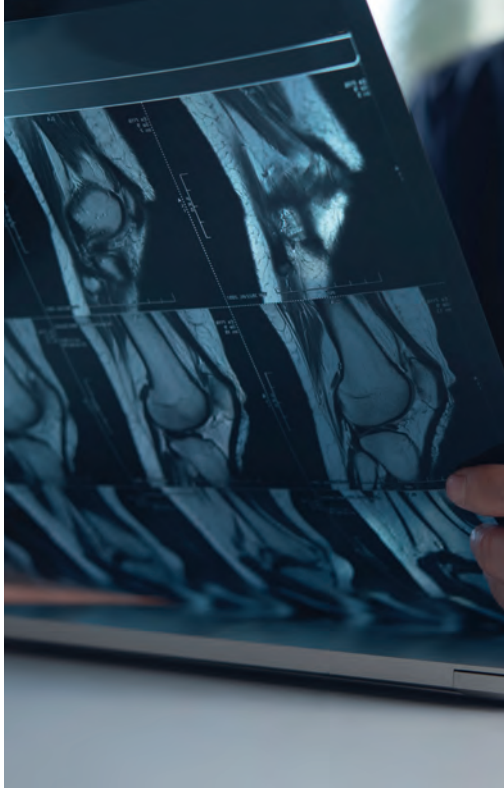
The full statement can be read online.

bit.ly/3MmlCog

POLICY UPDATE

Shine a light on workforce issues

Sean Edmunds, the Institute's External Relations Manager, outlines recent key policy updates.



A Health Minister has responded to the workforce shortages in medical physics and clinical engineering (MPCE) highlighted by IPEM.

Earlier this year, IPEM released a statement on the workforce shortfalls and recruitment outlook within MPCE, which restated calls for urgent action to be taken to address the shortages in this crucial area.

Letters were sent to several MPs to highlight the depth of concern among the MPCE workforce about the current state of provision within healthcare science. They were sent before the publication of the *NHS Long Term Workforce Plan*.

Will Quince MP, the Minister of State for Health and Secondary Care, did respond, albeit after the publication of the workforce plan, to say the government recognised the current pressures facing the NHS workforce.

Additional funding

In the letter, Mr Quince stated the *NHS Long Term Workforce Plan* set out the steps the NHS needs to take to deliver a workforce which meets the changing needs of the population over the next 15 years.

He stated the government was backing the plan with more than £2.4 billion over the next five years to fund additional education and training places.

He added: "We know healthcare scientists provide a vital service within the NHS, which is why the plan sets the ambition to increase training places for healthcare scientists by 13% to more than 850 places by 2028/29. This will put us on the path to increase training places by more than 30% to over 1000 places by 2031/32."

Mr Quince concluded by stating he would be meeting with NHS England's Chief Scientific Officer to discuss workforce concerns and said he understood IPEM had been invited to help take forward work to improve workforce intelligence in this area to ensure concerns are addressed.

Disappointing

Dr Robert Farley, who was IPEM's President at the time the letter was received, said: "It's very positive to get a response from the Minister. While he talked in broad terms about increasing the numbers of healthcare scientists in general as part of the NHS workforce plan, there was no specific mention of the medical physics and clinical engineering community, which is disappointing.

"We have, however, raised the issue of workforce shortages within MPCE at the

THE CHALLENGES OF ARTIFICIAL INTELLIGENCE

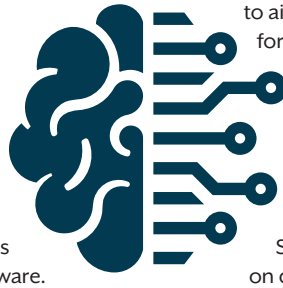
Artificial intelligence (AI) in healthcare science has, like in many areas, been a hot topic and IPEM has been responding to consultations on the subject.

The House of Commons Science, Innovation and Technology Committee launched a consultation about the governance of AI in October 2022 and has now published its interim report.

IPEM submitted a response to the consultation, which was led by IPEM's Clinical and Scientific Computing Special Interest Group (CSC SIG).

Dr Robert Ross, Chair of the CSC SIG, said the interim report provided a good summary of the challenges of AI and the absence of specific rules around it.

He added that while the interim report did highlight some of the benefits AI can bring to healthcare, it did not address the environmental impact of AI, which uses huge quantities of energy and hardware.



A response was also submitted to the National Institute for Health and Care Excellence on AI technologies to aid contouring for radiotherapy treatment planning.

IPEM's AI Working Party and the Radiotherapy Professional Standards Panel led on drafting a response to this, which was both supportive about the approach being taken and made several valuable suggestions.

IMAGES: ISTOCK/SHUTTERSTOCK

There was no specific mention of the medical physics and clinical engineering community, which is disappointing

WE HAVE RAISED WORKFORCE SHORTAGES AT THE HIGHEST LEVELS

highest levels within government and we will continue to highlight this whenever we can."

Towards the end of the year, two reports by IPEM's Workforce Intelligence Unit continued to shine a light on the workforce issues, this time highlighting staffing concerns within the ultrasound physics workforce and the magnetic resonance physics workforce.

The ultrasound report found services were being provided by an overworked and under-appreciated workforce. It revealed a workforce which has not grown, is under significant stress, with little capacity or resources for training, whilst there was an increased demand for the service.

It also found a vacancy rate in ultrasound physics of 23% for Clinical Scientists and 14% for clinical technologists – a significantly higher figure than for other medical physics specialisms.

The magnetic resonance physics workforce report also found that MRI services are in desperate need of more scientific support staff to meet current and future demand.

It revealed a workforce which, whilst small in comparison to other MPCE specialisms, has a higher-than-average vacancy rate of 12%, rising to between 13–14% for certain NHS pay bands.

The report stated the workforce needs to increase by 45% to meet current demand, and by more than double that to meet anticipated demand in three years' time.

THE BIG DEBATE

Horizon Europe

We ask a panel of experts about rejoining the EU's key funding programme for research and innovation, Horizon Europe, and the implications for medical physics and clinical engineering.

Q ***What are the benefits of rejoining? What specific advantages and opportunities will the United Kingdom gain by rejoining Horizon Europe?***

ADAM

The most tangible benefit is access to funding. Horizon Europe has a budget of €95bn for 2021-27. As a comparison, the UKRI budget is about £8bn per year. The income to UK research from Horizon Europe depends on success rates, but it is likely to be in the same ballpark as the annual budget for EPSRC, the main research council for most medical physics and biomedical engineering.

Less tangible benefits may be equally important. They include access to the world's largest research collaboration network and to the expertise and facilities of European researchers. Horizon Europe extends beyond the EU and indeed beyond Europe and also includes Israel, New Zealand and Turkey. Being a full member of Horizon Europe gives UK influence over funding policy and priorities. Membership may help movement and retention of researchers between countries, although loss of freedom of movement is a bigger hindrance.

BENJAMIN

Horizon Europe is one of the largest research and innovation programmes globally, with a substantial budget of €95.5 billion allocated to support scientific research and innovation. Re-joining Horizon Europe will enable access to the funds, but it will also allow the UK to collaborate more easily with European researchers and institutions, fostering international research networks and partnerships. Economic benefits will be realised through the creation of new technologies, products, and services that have economic potential. As a Horizon Europe participant, the UK could have a say in shaping the programme's research priorities and agenda, and the UK would become more attractive to international researchers and innovators.

MAGDALENA

Horizon Europe is the world's largest research collaboration programme. With a budget of nearly €100bn dedicated to research and innovation it covers virtually any aspect of the scientific research, collaboration, and what is more important, it contributes to the global sustainability of the member organisations and the entire region. Rejoining Horizon Europe brings UK scientists back to where they have always belonged – fully associated members for the remaining part of the Horizon Europe programme, opening opportunities to apply for grants and take part in projects, and eventually join the governance of EU programmes.

SLAVIK

The problems related to climate, energy, diseases and other challenges in front of humanity can only be addressed by large international teams. Horizon Europe is perhaps the largest international (EU) activity aiming to deal and potentially give solutions to these challenges. Its enormous budget of nearly €100bn indicates the importance which all EU countries' leaders place on science. Britain has been a very important contributor to past EU projects and should join the team working together for the benefit of humanity. The question here is not about the immediate benefit of receiving financial funding, but for the long-term benefit of the results of this international collaboration.

IMAGES: ISTOCK/SHUTTERSTOCK

PADDY

In my opinion, both the current states involved in Horizon and the UK medical physics community will benefit from UK's re-joining Horizon Europe. The United Kingdom has been a beacon in medical physics practice and research. This year's theme for international medical physics day is "standing on the shoulders of giants". It is easy to see many of these giants, such as Prof Mallard, Prof Mansfield, and Sir Geoffrey Hounsfield, came from the UK. In more recent times any EU or other projects we have been involved with through the European Federation of Organisations for Medical Physics (EFOMP) have produced excellent results and symbiosis.

TRACY

UK-based scientists are now once again able to apply for the full suite of Horizon grants, which fund everything from personal postdoctoral fellowships to large collaborative research networks which can involve universities, hospitals, and industrial partners, from >10 different countries.

Q ***What are the costs and obligations? What financial commitments and obligations will the UK incur upon rejoining?***

ADAM

It is not easy to find the exact costs of membership. This is partly because the agreement allows for the costs to be adjusted if the success rates of UK applicants fall

MEET THE PANEL

PROFESSOR ADAM GIBSON

Former IPEM Vice President Academic.
Professor of Medical Physics
University College London

DR BENJAMIN METCALFE

IPEM Vice President Academic.
Head of Department – Electronic and Electrical Engineering
University of Bath

PROFESSOR MAGDALENA STOEVA

Secretary General International Union for Physical and Engineering Sciences in Medicine

SLAVIK TABAKOV

History Sub-Committee Chair and Former President International Organization for Medical Physics

PADDY GILLIGAN

President European Federation of Organizations for Medical Physics

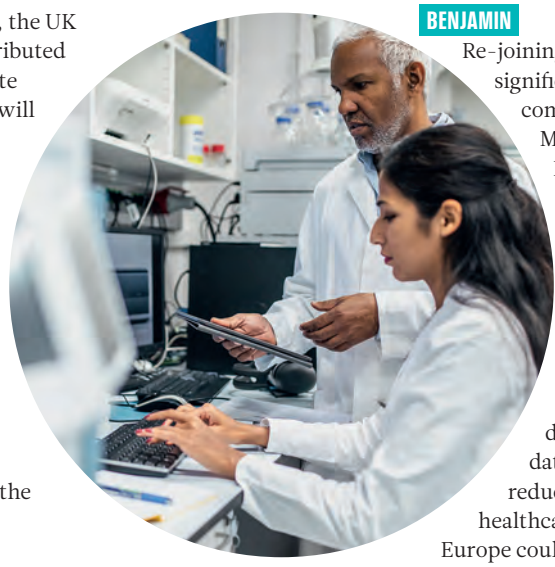
DR TRACY UNDERWOOD

Head of Translational Research
Leo Cancer Care

above or below thresholds. Before Brexit, the UK used to receive more money than it contributed to Horizon Europe but now as an Associate Member that will be tracked and the UK will have to pay its share.

BENJAMIN

The overall cost to the UK is expected to be £2.1bn a year for access to Horizon Europe. Importantly, the UK typically received about £2.2bn from the scheme in funding before Brexit and there are compensation clauses in the agreement that are designed to kick in if awards to the UK are 16% lower than contributions. There has also been an agreement that the UK will not pay in to the scheme until 2024.



MAGDALENA

It is difficult to discuss financial commitments and obligations at this point as the final goal and benefit for the UK-based scientists and organisations will exceed the initial investment bringing benefits not only at scientific, but what is more important, at societal level. Despite the fact UK has already declared the financial terms for rejoining the Horizon programme are very favourable for the taxpayers, there still seems to be significant amount of concern within society. This must be dealt with through active campaigns clearly explaining the investment-benefit ratio and the final objectives of the rejoining through the prism of societal good.

PADDY

Obviously, there is a UK contribution and certain sources quote this as being of the order of €2.6bn per annum for Associate Membership. This is against a backdrop of a total Horizon fund of €95.5bn per annum. The UK was the greatest beneficiary of the Horizon 2020 programme. There had been a fund from UKRI of £1bn over the last three years for a guarantee scheme for projects involved in Horizon.

Q ***What is the impact on scientific research and innovation? How will rejoining Horizon Europe affect the UK's scientific community and innovation ecosystem?***

ADAM

A proportion of the Horizon Europe budget is allocated to innovation, similarly to UKRI funding innovation, and research feeds through to innovation eventually.

BENJAMIN

Re-joining Horizon Europe could have several significant effects on the UK's scientific community and innovation ecosystem. Many of the research projects funded by Horizon Europe are focused on global challenges, such as climate change, healthcare, and sustainable development. Our involvement in these initiatives would enable us to contribute to global impact and innovation on a scale that we cannot do in isolation. Participation would also grant UK researchers access to valuable datasets and research findings, facilitating data sharing and knowledge exchange and reducing duplication. Importantly for healthcare innovation, re-joining Horizon Europe could also lead to greater regulatory alignment with the European Union.

MAGDALENA

We all expect not only a positive impact, but also a long term one with clearly set research and innovation priorities. What is more important is the impact should not be isolated within the scientific communities but manifested within the entire societal and economical scope through translation, engaging business and communicating the long-term goals and benefits to the community.

SLAVIK

I was involved in 10 EU projects, coordinating seven of these. I also took part in various UK and EU fora, discussing and assessing many EU projects. On this basis, I can firmly state that the UK had a very prominent role in almost all EU projects with our participation. UK scientists were respected as valuable members of all project teams. The innovations created by these projects can be seen in many places. Unfortunately, contrary to many other countries, in the UK there was limited visibility of these projects and their results. The latter reduced the public appreciation of EU-funded research. Rejoining Horizon Europe (and other EU activities) will bring benefit both to UK and EU. International scientific collaboration has always been very effective in solving global problems.

"INTERNATIONAL COLLABORATION HAS ALWAYS BEEN VERY EFFECTIVE IN SOLVING GLOBAL PROBLEMS

Our contribution to medical research will be of benefit both to us and to the other colleagues in EU countries, and from there, as spin off effect, globally.

PADDY

Much of modern research is done through exchange of ideas, talent and skill sets. A lot of what we are seeing now in radiological research involves larger data sets both for epidemiological effects and for the assessment of new technologies, such as particle therapies, new radionuclide therapies and artificial intelligence techniques. The purpose of EFOMP, which was founded in London in 1980, is to communicate, integrate and educate. Research collaborations provide the ideal platform for this.

> **"THESE RELATIONSHIPS CAN FLOURISH AND BEAR FRUIT FOR DECADES AFTER INDIVIDUAL GRANTS EXPIRE**

TRACY

Horizon Europe is about far more than money in/out. It fosters collaborations between leading institutions worldwide, enabling knowledge and skills to be transferred across borders. This accelerates scientific progress. The Horizon scheme also exposes young scientists to international and diverse ways of thinking and working. It provides unique opportunities for individuals to experience "best practices" in global science and to carry those practices forward throughout their careers. It also enables personal collaborative relationships to be formed: these relationships can flourish and bear scientific fruit for decades after individual grants expire.

Q *What alternative funding mechanisms exist? Are there alternative avenues for funding research and innovation that the UK could explore if it decides not to rejoin Horizon Europe?*

BENJAMIN

There are alternative avenues for funding, but none on the same scale as Horizon Europe. National funders such as UK Research and Innovation (UKRI) provide funding to UK researchers but do not typically support collaborative international research. There are some charitable foundations, such as the Bill and Melinda Gates Foundation, that offer funding in specific fields such as medical research or environmental conservation, but again on a very different scale to Horizon Europe. Bilateral agreements exist with countries including the US and Canada, and in some cases national funders can match fund international collaborations. Importantly, unlike Horizon Europe, none of these alternative schemes were designed from the ground up to support large scale international research and innovation.

MAGDALENA

The decision to rejoin is already a fact and from this point forward the last question should probably sound better if change to "... UK could explore after rejoining Horizon Europe?" And the answer of course is "yes". Rejoining the Horizon programme does not exclude opportunities for alternative funding using UK national programmes, support from the industry or participation in other regional or global ventures. However, Horizon Europe is unique.

SLAVIK

The alternative UK and international funding activities would not have the wide international impact and dissemination of EU projects. The broad implementation of EU project results in many countries brings not only momentary effect, but also international reputation of UK science, what on its turn reflects in various other areas of social life, and indirectly benefits UK universities and business. In the current difficult situation on our planet, the question of international collaboration is not simply related to momentary financial benefit. The big goal is for the human race to survive the enormous challenges in front of the life on the planet. Britain can be an excellent and highly respected interface between European research and other global research, such as US-led research.

PADDY

I was under the impression that the UK has decided to join again in January 2024, but this has to be finalised. For the last three years there has been a guarantee scheme referred to above. Of course there are always alternative sources of funding through philanthropic organisations, commercial investment and other initiatives. UKRI also provided significant funding too over the last number of years.

TRACY

One example is the UKRI "Future Leaders Fellowship" scheme, which in some ways has acted as an alternative to Horizon Europe's personal grant funding schemes. However, the UKRI scheme does not specifically encourage international collaboration, nor does it require applicants to experience research environments outside of the UK.

Q ***What are the implications for future relationships with the EU? How might the UK's decision to rejoin Horizon Europe impact its broader relationship with the European Union?***

ADAM

It's hard to say. There is a lot of soft power in developing relationships between universities and academics, and if membership of Horizon Europe is seen to be successful by government then it can't harm the broader relationship, but my impression is that this is unlikely to lead directly to further closer relationships with the EU.

BENJAMIN

Truly impactful and collaborative research and innovation does not have borders. Academics around the world continue to work with each other, despite funding challenges, and the decision to re-join Horizon Europe will be seen as a positive signal of the UK's willingness to cooperate with the EU and will foster a sense of collaboration and trust in EU-UK relations. It may also serve as a precedent for the negotiation of similar agreements across areas such as security and trade. Of course, the detail of the complex relationship involving issues around budgets, intellectual property rights and governance may continue to cause friction. Ultimately, the decision to re-join should only be seen as a positive step towards constructive engagement with the EU.

MAGDALENA

It is difficult to see any potential risks or major implications such a decision may bring to the scientific community in the UK. I rather expect relief and increased opportunities than facing difficulties. Following the restrictions Brexit brought to scientific life, rejoining Horizon will easily turn into a driving force revealing numerous opportunities for cross-border and cross-platform collaboration.

SLAVIK

All EU projects, those I know and/or worked on, were very successful – these created the first-in-the-world educational e-books with ISBN number, the *e-Encyclopaedia on Medical Physics* and its *Scientific Dictionary*, the first educational website in medical physics. Thousands of colleagues per month use these materials globally. This directly reflects on the reputation of our science and our international relations in a broader sense. Surely this will reflect on other political/social activities related to the broader relationship with the European Union. However, it is important for the results of our scientific collaboration to have wider publicity in the UK, what was neglected in the past – e.g. when our team received the EU inauguration prize for vocational education, the Leonardo Da Vinci Award, this was included in all main media in the EU and in the TV EuroNews, but not in the UK media or TV...

PADDY

For those of us who reside in the EU we feel that there has been a warming of relationships under the current government in more recent times. Unfortunately, the patients and medical physicists can get lost in broader political issues when we share common goals and common challenges in treating and diagnosing patients post pandemic. It would be nice to see Erasmus being added back again as part of future agreements.

Q ***What are the specific research and innovation priorities? What areas of research and innovation does the UK government prioritize, and how do these align with the goals and focus areas of Horizon Europe?***

ADAM

Horizon Europe aligns itself closely with the UN Sustainable Development Goals but has identified five "missions areas" of climate change, cancer, healthy water, climate-neutral cities and soil health. UKRI tends to set higher level goals like "infrastructure" and "skills". Specific research priorities are delegated to the research councils who then give rather fine-grained priorities. The current Strategic Delivery Plan for EPSRC, for example, has eight priorities which include "transforming health and healthcare" and "artificial intelligence, digitisation and data".

The priorities of the different bodies tend to overlap but not align closely. For example, UKRI has a fund dedicated to "ageing society" which would overlap somewhat with Horizon Europe's mission of "cancer".

BENJAMIN

The majority of UK government-funded research is directed and funded via the nine bodies that constitute UKRI. UKRI has a five-year strategy – Transforming Tomorrow Together 2022 to 2027 – that outlines the key strategic themes and priorities. There are five themes, several of which encompass healthcare or healthcare related research including "securing better health", "ageing and wellbeing" and "tackling infections". Each theme is allocated approximately £75m for the duration of the five-year strategy. The UK government also funds research via the National Institute for Health and Care Research (NIHR), In comparison with UKRI, NIHR focusses on translational research and clinical research, with an annual budget in the region of £1.2bn.

Horizon Europe has identified six clusters of activity, of which health is one. It aims to improve health and well-being through the generation of new knowledge and innovations to prevent, diagnose, treat, and cure diseases. Within this cluster there are six specific areas of intervention, ranging from technologies for personalised medicine through to health care systems and environmental and social health determinants.

MAGDALENA

Setting up priorities when it comes to research and innovation is quite challenging as one should always consider the long-term prospective, as well as being mindful when it comes to proper allocation of public funding and future influence on the development of scientific community and society. The UK government seems to have found a good balance between the traditional subjects and the innovative cutting-edge research, but still a long way to go to establish productive public-industry partnerships at nationwide scale.

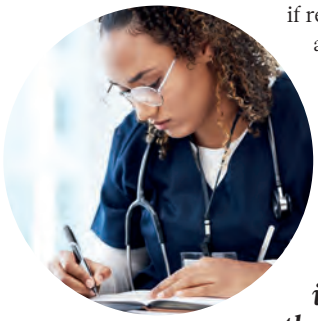
SLAVIK

These are very often political questions (both in EU and UK) and these might change over time. However questions related to medicine are inevitably one of the important priorities of every research and innovation programme.

"QUESTIONS RELATED TO MEDICINE ARE ONE OF THE PRIORITIES OF EVERY RESEARCH AND INNOVATION PROGRAMME

PADDY
The focus areas of Horizon Europe are: adaptation to climate change, including societal transformation, cancer, soil health and food, climate-neutral and smart cities, healthy oceans, seas, coastal and inland waters. From a medical physics perspective, I think the challenge post-pandemic is the catch up and accessible health care. Such research also has to meet the sustainable development goals as identified by the United Nations. Apart from the specific mention of cancer and infection (which just reflects emphasis rather than overall strategy) the UKRI and the EU Horizon five areas are similar: building a green future, building a secure and resilient world, creating opportunities, improving outcomes, securing better health, ageing and wellbeing, tackling infections. I do not see these being any less relevant anywhere in the world and these objectives rise above political considerations.

TRACY
Recent UK governments have encouraged business-led innovation, particularly through bodies such as Innovate UK. This strategy aligns well with Horizon Europe, which recognises that ambitious partnerships between academia and business are often essential if research is to lead to high scientific, societal and economic impact.



Q ***How will rejoining impact UK universities and research institutions? What benefits and challenges will UK universities and research institutions experience if the UK rejoins Horizon Europe? How will this affect their funding, collaborations, and competitiveness?***

ADAM
Research income is, of course, a big help. There has been government support for UK researchers who applied to Horizon Europe and were successful, so this funding stream never dried up completely, but it certainly slowed down significantly. The European Research Council Fellowships are seen as very prestigious and can be a way for researchers to establish their research groups. International collaborations benefit researchers from sharing knowledge and facilities, and there are training and travel opportunities such as through Marie Curie Fellowships. However, these opportunities may still be limited by loss of freedom of movement of researchers, especially those with families.

MAGDALENA
Universities and research institutions may be considered the primary (short-term) beneficiaries of the Horizon programme and associated funding. In the scope of the good pre-Brexit traditions for scientific collaboration cross-border/cross-channel UK academia can easily re-establish the good practices from the near past and use this a jump-start to the extended Horizon project term. Brexit (Brit-Exit) finally found a counterbalance in the Brizon (Brit-Horizon) as far as science and innovation are concerned.

SLAVIK
Rejoining will reflect on more European students coming to UK universities (MSc and especially PhD), which again brings direct benefits not only to projects, but also any other research activities. UK universities benefit directly and indirectly from more European students, who not only have very good English, but also with similar educational/scientific background which facilitates research.

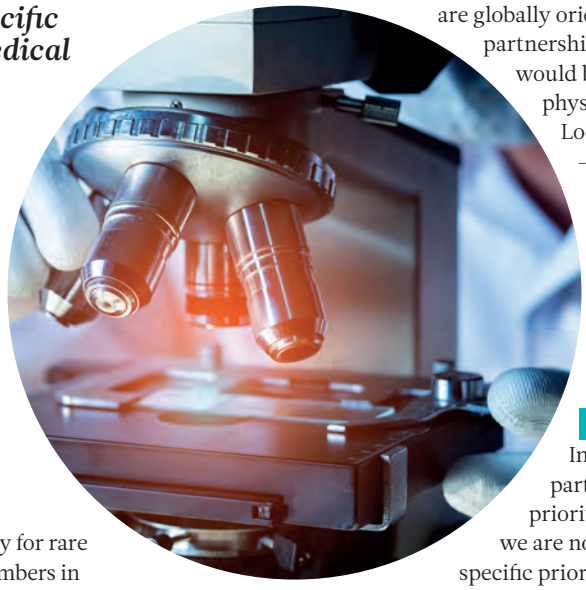
In longer perspective, when these students return to their countries, they are strong supporters of UK scientific and cultural life. From another angle some UK universities are reluctant to join EU projects, as these universities have been accustomed to request huge overheads (often over 100%) from some other research funding activities, while EU projects have fixed overheads (usually below 50%), as these projects require the funding to go mainly to the scientists.

PADDY
One would hope that they would enhance funding, collaborations, and competitiveness. There may be challenges if certain projects have proceeded without UK involvement and how they might re-engage UK scientists. Cross-institutional and cross-country collaborations may be affected by different regulatory environments within and outside the EU, such as data protection, medical devices regulation and radiation protection considerations.

TRACY
Eligibility to apply for/hold Horizon funding makes the UK far more attractive as a destination for scientific talent. The Horizon programme will also help us to retain top scientists who are already working in the UK.

"ELIGIBILITY TO APPLY FOR HORIZON FUNDING MAKES THE UK FAR MORE ATTRACTIVE AS A DESTINATION FOR TALENT

Q ***Is there anything specific within the field of medical physics and clinical engineering which will be aided by the UK being a member of Horizon Europe again? What should be some of those priorities in terms of research and innovation?***



ADAM

From the point of view of IPEM members, membership of Horizon Europe should help researchers to share sensitive patient data with collaborators in other countries, and should help with recruiting large patient cohorts especially for rare diseases, which will be beneficial for members in areas such as proton therapy. It may help with movement of equipment and researchers across borders, although costs and paperwork associated with customs and loss of freedom of movement of researchers and their families still lead to additional challenges for research collaborations between UK and European partners. I believe there are still complications around recognition of qualifications and expertise between countries which I don't think are solved by membership and will need further negotiation.

BENJAMIN

Horizon Europe directly supports and facilitates research covering medical devices and clinical trials, so UK researchers can now access funding and networks to conduct clinical trials, validate medical devices, and develop novel healthcare technologies, with a direct impact on patient care. Enhanced access to health data and research efforts in fields such as genomics and medical informatics will lead to more personalised and effective healthcare solutions. Importantly, there is the opportunity for further regulatory alignment that could simplify the process of certifying and deploying new medical devices across Europe. Research priorities should be aligned so that the development and deployment of new devices and technologies is undertaken in alignment with developments in healthcare systems, but put simply our association with Horizon Europe will be a game changer in our ability to achieve demonstrable impact at scale, improving health and wellbeing for all.

MAGDALENA

Unlike many disciplines which are regionally focused, medical physics and biomedical/clinical engineering are globally oriented and, as such, extending partnerships and communication networks would be extremely beneficial for medical physicists and engineers in UK and EU. Looking from the pure practical side – both the IOMP (International Organization for Medical Physics) and the IUPESM (International Union for Physical and Engineering Sciences in Medicine) are headquartered in the UK and rejoining Horizon Europe will open numerous of opportunities to both these global organisations.

SLAVIK

In the past UK scientists took an active part in the EU discussions of the specific priorities of various EU programmes. Now we are not involved, hence we cannot influence specific priorities. Rejoining will deliver to our medical physicists and engineers the possibility to include our specific priorities... and what will be these is a question for the young scientists to discuss and select at the time when this rejoining becomes a reality.

PADDY

Absolutely – projects involving multiple skill mixes or to generate, such as dosimetry studies in radionuclide therapies, or large data sets and outcomes in artificial intelligence or cancer studies, low level radiation epidemiological studies. These are but a few of the many projects which would benefit. There also needs to be research in eliminating barriers and assessing potential in high tech health care including particle therapies, including access, knowledge exchange to serve the patient demographic. It is a key objective of EFOMP to propose a common training platform to facilitate mutual recognition of medical physics experts in the 36 national member organisations (27 in the EU, nine outside the EU).

TRACY

Considering proton/ion radiotherapy as an example, there have been a number of very successful doctoral training networks in this area, funded by Horizon Europe (e.g. PARTNER, ENLIGHT, RAPTOR). These networks unlock outstanding training opportunities, not just for the PhD students funded directly by the Horizon grant, but also for their colleagues – additional researchers and clinical staff – who are eligible to participate in the network training programmes. Personally, I see tremendous value in Horizon doctoral training networks and other Horizon programmes, and I hope that the UK will be involved in many more in the field of medical physics.

RISE OF THE ROBOTS?

ARTIFICIAL INTELLIGENCE: A PRIMER

Radiotherapy Physics Clinical Computing Lead **Robert Ross** with the first instalment of a new series investigating artificial intelligence (AI) in medical physics and clinical engineering.

AI is going to kill us all. Or is it humanity's saviour? You can't have missed talk of AI in the media recently. ChatGPT has taken the world by storm and brought AI from sci-fi films into everyday language. Many of the articles in media quote "experts" and declare AI to be an existential threat to humans. Or they claim it is our digital saviour. Most of these articles are clickbait, designed to attract attention (and advertising) rather than to provide an informed and balanced account of what AI is, what it can do for us, and what it can't do. As with anything, there are kernels of truth in the clickbait, but reality is less dramatic, yet full of opportunity and risk. It will revolutionise what and how we do things, in ways we can't yet imagine. People overestimate the short-term impact of technology while underestimating the long-term impact – how many of us thought the World

Wide Web would change how we shop, how many of us knew social media would be so polarising? AI is here to stay and it will be transformative in healthcare. Strap yourselves in – smart software is going to change your job.

This *Scope* article is the first in a new series on AI in medical physics and clinical engineering (MPCE) disciplines, exploring the impact of it on the services we provide and support, both currently and in the future. We begin here with a primer on what AI is (and what it isn't).

Defining AI

You might be a bit confused about what AI actually is. Annoyingly, there is no single definition. Use of the term appears to be evolving to include any non-procedural method of problem solving. AI uses statistics and algorithms to solve problems such as categorising data or creating a mathematical model. It is different to procedural analysis, where humans give a computer an explicit list of instructions to process data. Instead, we give the computer tools so it can work out the required solution itself. Table ❶ on page 28 gives some more definitions commonly used when talking about AI.

I suggest a functional definition is that AI is less about "intelligence" and more about judgement, though one could argue we need intelligence to have good judgement. As a concept, "intelligence" has connotations of understanding the subject at hand – AI doesn't do this. It can judge how well variables correlate, or it can judge if a flower is a buttercup or daisy, or it can script a human-like response to a question, but it understands nothing. It has simply found a rule that gives the required output for a given input, which means current AI systems have a narrow scope. They can do one task well, but they can only do that one task.

A classic machine learning (ML) example is to classify photos of two types of flowers. Rather than give the computer rules such as "forty-two white petals = daisy" and "five yellow petals = buttercup", we give it the daisy photos and say "these are daisies" and we give it the buttercup photos and say "these are buttercups". This is the training data for the training phase. We also give it the tools to analyse the photos, such as ways to identify the petals. Then we tell the computer to work out a rule, or model, to classify the photos into "daisy" or "buttercup". This model can then be applied to photos the computer hasn't seen before. This example uses supervised learning, as we label the pictures as "daisy" or "buttercup" (see table ❶ for definition). Importantly, the rule that the ML algorithm finds may not be what a human would determine to be the rule. When categorising "daisy" or "buttercup", the computer might simply be counting how much of the image is yellow and how much is white. Constraints

"AI CAN JUDGE IF A FLOWER IS A BUTTERCUP OR DAISY, BUT IT UNDERSTANDS NOTHING

can be applied, such as telling it to count the petals. To categorise daisies and buttercups, we need to give lots of photos of these to the computer. But are my photos truly representative of daisies and buttercups? This brings us into data curation and bias.

Data curation, bias and ethics

Where did my photos come from? Maybe I took all the photos in my local area and assumed all daisies look alike and all buttercups look alike. But maybe my local area has an unusual kind of daisy with more petals than anywhere else in the country. If I apply the classification rule to a photo from the internet, will it be correctly classified? It is possible that the training data, being biased to my local area, will give incorrect results for flowers from other areas – the model is not evaluating all regions' flowers to the same level of accuracy. This might not matter if it will only be used in my local area, but if I want to sell this categorisation solution across the country, or the world, I need to be careful about this bias. To ensure the training data is representative of the flowers in the countries I'm going to sell the solution in, I need to know where the photos come from and I need to statistically analyse them to make sure no country is over- or under-represented.

Bias is a real concern when it comes to human data. AI has been used to classify people into "likely criminal" or "likely not criminal" in the US, based on photos of convicted criminals and photos of people without criminal records. With endemic institutional racism, people of colour in the US are more likely to be convicted of crimes than white people so are over-represented in photos of convicted criminals. AI systems without bias controls quickly determine that a key feature in the training data is that darker skin colours are more likely to be criminals, with the result that it determines people of colour are more likely to be criminals than white people – the AI hasn't learnt to identify criminals, it has learnt to be institutionally racist.

In healthcare, we face biases in our data. Many commercial healthcare products are developed in the US, where healthcare is not universally free for residents. This potentially means the data being used to train AI is biased towards those who can afford healthcare – and again institutional racism means these are more likely to over represent white people. People who can afford healthcare are also more likely to be healthy, though interactions with healthcare also increase with age. AI solutions may give good outcomes when applied to the healthy, wealthy elderly, but may deliver inferior healthcare to those outside the training data demographic. Capturing data for training AI systems also – in many cases – involves capturing and analysing the demographic data for that patient; age,

Figure ❶ Simple mathematical function describing an artificial neuron n, summing the products of i inputs which are weighted by wi. A bias is applied to the summed products.

$$n = \Sigma w_i \, input_i + bias$$

Figure ❷ Graphical representation of an artificial neuron, with three inputs and one output.

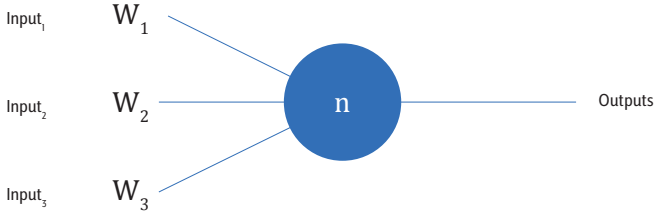
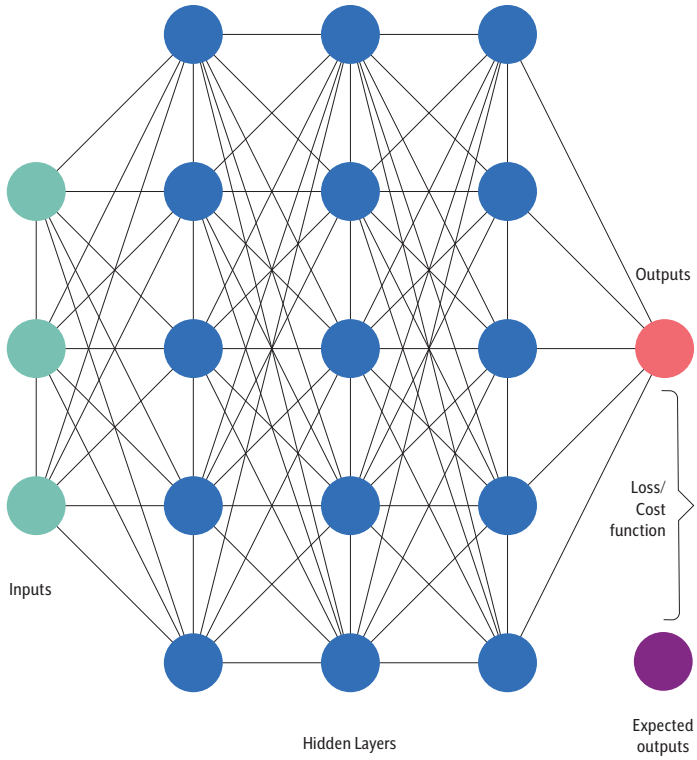


Figure ❸ Representation of an artificial neural network. Green circles are neurons that received inputs, red circle is the final neuron delivering the calculated outputs, which are compared to the expected output (purple circle) Blue circles are hidden neurons, taking their inputs from preceding layers and passing their outputs to subsequent layers. Lines represent connections between neurons.



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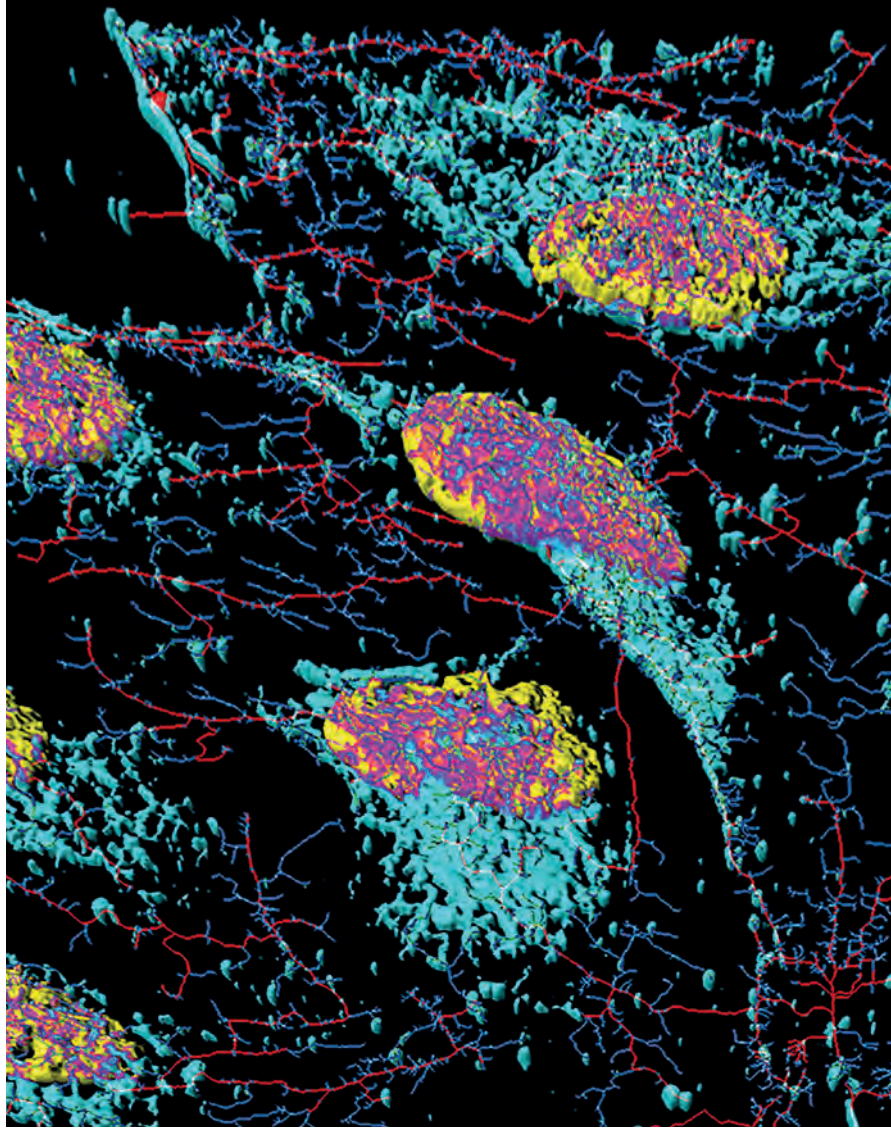


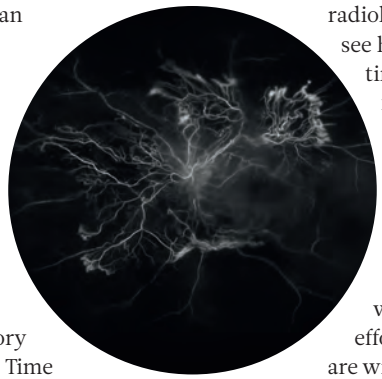
weight, sex. Potentially, we also need relevant medical history data, depending on the application.

Healthcare centres across the globe capture voluminous data about patients. But can we use it? Ethically, patients should be able to consent to their data being used for research, particularly if commercial solutions are developed from that research. (Famously, the HeLa cell line - on which decades of research has been conducted on, with large profits being generated – was taken from Helena Lax without consent from, or payment to, her or her family). Consent to use patient data in research, especially for commercial benefit, is not always clear-cut. A patient may feel they must consent to the research or risk being denied healthcare. Or they may not understand exactly what they are consenting to. Kidney patients may be willing to consent to their data being used for research into their condition, but for classification problems we need training data on pathological kidneys and non-pathological kidneys – but if you are undergoing healthcare for a lung problem, you likely aren't thinking about your kidney data being used for AI research. Is it ethical to use patient data in this way, when explicit consent has not been given? What steps do researchers take to ensure the patient hasn't opted out of consenting to using their data for any research? Is it ethical to not leverage the voluminous data to improve healthcare outcomes? How do we, the purchasers in healthcare and the patients, have assurances about the ethics and biases of the products we buy? Openness and transparency are key. Companies producing AI software can publish their training data and results, or at least a summary of demographic data, though there may be commercial sensitivity around this. With all these concerns around data curation, bias and ethics, we might wonder if the benefits of healthcare AI are worth the effort.

Benefits of AI In healthcare

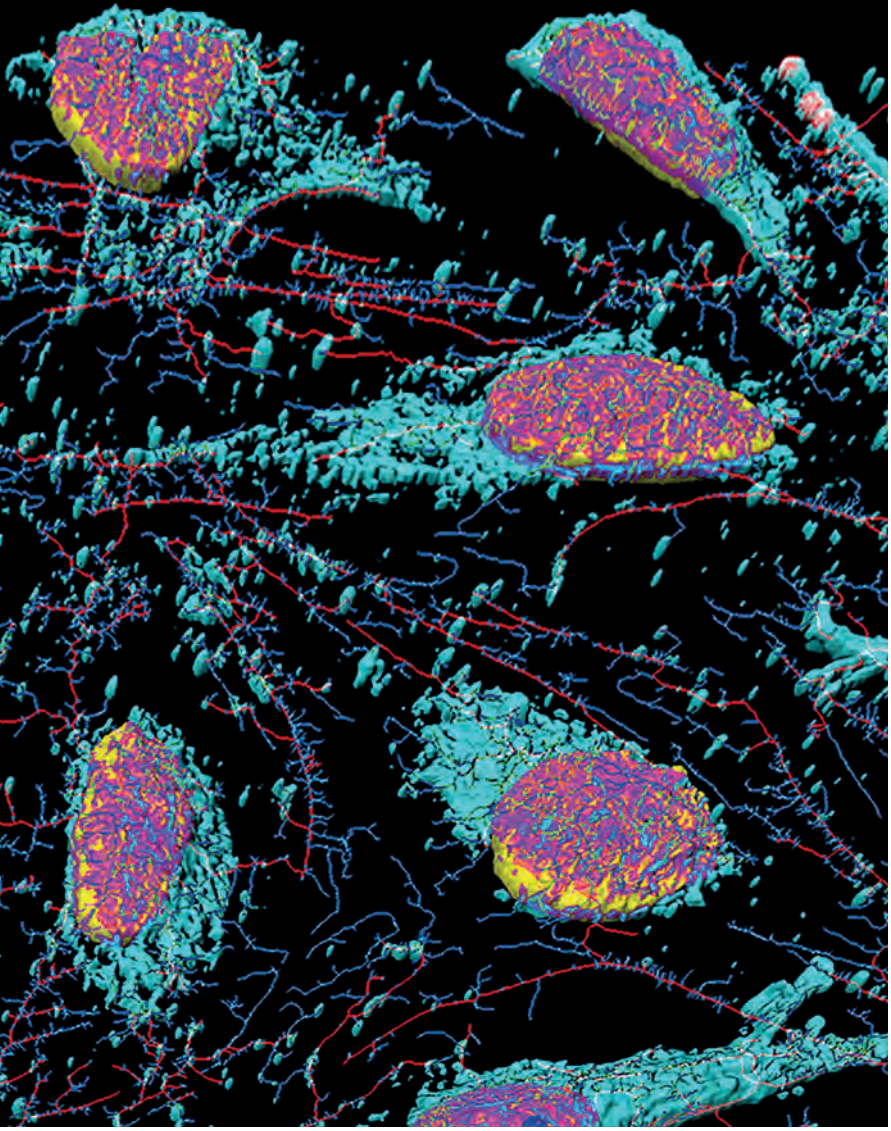
With demand for healthcare services outstripping growth in healthcare staffing levels, AI offers the potential to provide cost-effective expert judgement on repetitive tasks. In turn, this can free up clinician time. AI also offers new insights into diseases and treatments, further improving our ability to prevent, diagnose and treat illnesses. Clinical AI is a genuinely disruptive and multidisciplinary technology. Yet people often overestimate the short-term impact of new technologies while underestimating the long-term impact.

Numerous and varied potential applications of AI in healthcare exist, but the low hanging fruit is image interpretation. AI image interpretation theory is well established and we have vast stores of data. Time and cost savings can be quickly achieved in breast screening (identifying cancers), radiology, ophthalmology (retinopathy imaging), pathology (histology slide analysis), dermatology, image reconstruction, radiotherapy (contouring organs) and beyond. For scientists and engineers, AI is a tool we can use to enable research and development.



AI assistants can also help doctors, for example an AI could "see" a patient before the doctor does, asking about medicines and pulling notes together – this is the first 10 minutes or so of a typical doctor consultation in a clinic. AI reporting in screening programmes reduces radiologist reporting burden. But we are not likely to see highly complex or general purpose AI systems any time soon. Advances in AI seem more like they will find more efficient ways of training and implementing existing models, using less power, and deployment models may be more focussed on sharing resources between users.

Simple uses include writing reports – even just doing a first draft, or writing your abstract for a conference. It's a tool, and trainees can use it to write reports, which means we need to put more effort into ensuring students understand what they are writing about, e.g. through critical reflection.



“THE HELA CELL LINE - ON WHICH DECADES OF RESEARCH HAS BEEN CONDUCTED ON, WITH LARGE PROFITS BEING GENERATED – WAS TAKEN FROM HELENA LAX WITHOUT CONSENT OR PAYMENT

For researchers, AI could potentially produce whole-literature summaries and analyses and offer critiques of experimental designs (both proposed and in journal articles). Large scale literature reviews can be achieved quicker and to a high standard. Researchers can get an AI peer review of their research methodology prior to undertaking the work. Journals can get fast, unbiased and thorough article reviews without needing human time-poor volunteers.

AI can save human time on a task, freeing up time for other tasks, or it can do a task more consistently. Inputs and outputs for training and commissioning need to be evaluated; systems maintained, updated and decommissioned; workflows need to be considered and adjusted.

Longer term, we are likely to see increased adoption of these single-application systems. Non-healthcare specific applications of AI will feed into our workplaces, such as AI management tools that can help shape resource deployment and identify patterns in health, and personal assistants that can help us coordinate our workloads. Current AI methods are unlikely to see further game-changing approaches – there will not be any AI doctors or clinical scientists.

Risks of AI

A major fear about AI is its ability to replace humans. Intelligence, or the ability to make good judgement, is no longer uniquely human. As factory workers were replaced by machines, knowledge workers face replacement by AI. But healthcare is, almost globally, understaffed. Rather than take our jobs, AI will change them. Healthcare workers' roles and responsibilities will move from doing the repetitive tasks to ensuring that the AI is doing them safely, that it is correctly integrated into workflows and other systems. MPCE staff are well placed within multidisciplinary teams to support AI.

There will still be reluctance to embrace AI, as with any change. People like the familiarity of doing the things they have always done. Removing some of the judgement aspect of roles may also remove the creative, interesting part of the role, such as creating radiotherapy treatment plans for cancer treatment.

Threats of AI include getting things wrong – a threat to the patient's care. Outputs must be safe for everyone, including when using AI that is not a medical device within healthcare. One way outputs might not be safe is the use of biased data, where the AI model provides good health outcomes for one category of person but not another, driving health inequality. It is difficult to independently assess the bias, and to reproduce results, when the training and validation data (and the AI model) are not open access. Manufacturers and researchers don't have standardised metrics for reporting results, making comparison of similar AI products more difficult, and the reported metrics need to be meaningful. Without being able to evaluate the training data and models ourselves, or being able to compare similar metrics, we could struggle to ensure the products are unbiased.

AI doesn't necessarily produce the best output, there can be other ways to achieve it, e.g. simpler analytical techniques, or even just old-fashioned human effort,

if the effort of properly "doing AI" is greater than the predicted reward. AI is a tantalising new technology for people who like STEM and problem solving, but developing AI for problems where AI is not the best solution diverts precious time and effort from viable solutions.

AI algorithms find solutions, but not in the way a human does. One future advance in AI to enhance confidence is to get vendors to generate human-readable decision reports, telling us how the AI arrived at its decision, or which parts of images it struggled to determine an outcome for. This can help with adoption while also providing valuable feedback for the vendor. For screening algorithms, we can set them to flag any suspicion of pathology to a human doctor, though the more false positives that need reviewing, the less benefit there is of having an AI involved in screening. Sensitivity and specificity of AI assays must be carefully selected.

Other risks with AI can be around how it is deployed. AI can be licensed as software-as-a-service – basically an online subscription model, like Netflix – but what happens to our service if that vendor goes out of business, or if our internet connection goes down? Do we have the skills or time to deliver the service safely? Another concern is that these systems can be expensive, even if we can actualise cost savings from the system – and that's a big "if".

AI could also be a threat to our strategic environmental goals. Considerable power is used in AI processing and training, contributing to CO_2 emissions. The hardware required to train and run AIs increases demand for rare earth materials and generates increased electronic waste. But there may be ways to optimise or mitigate this. When we horizon scan for AI applications, we need to be cognisant of the environmental impacts of the available options and how they meet or defeat our environmental goals. To this end, specialists in AI will be required – people with the knowledge, skills and experience to advise on all aspects of implementing and monitoring AI.

Underestimating the long-term impact of new tech is easy, but I believe the increasing demands on healthcare,

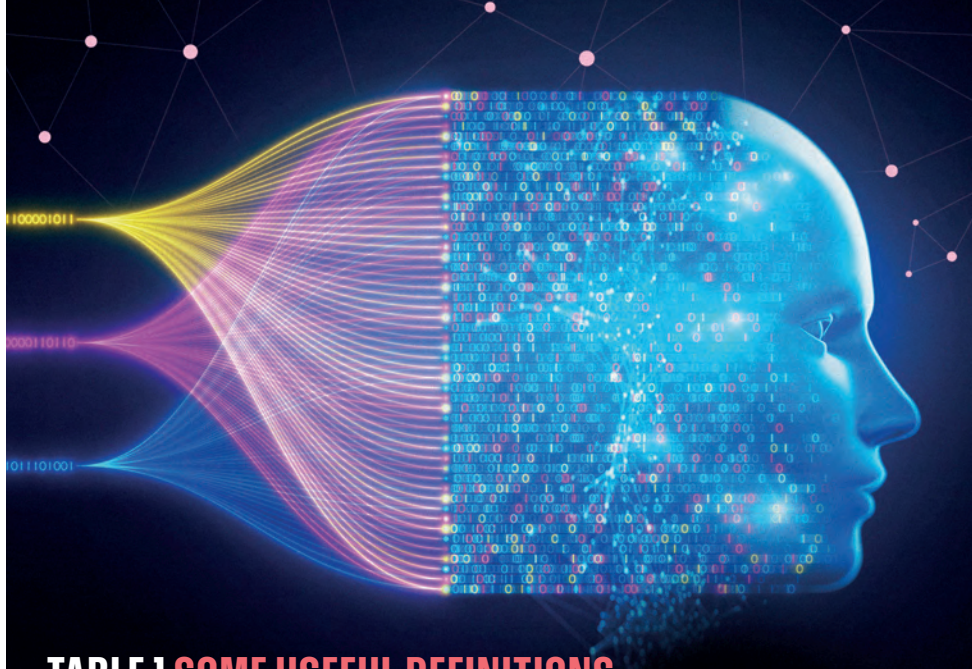


TABLE 1 SOME USEFUL DEFINITIONS

Artificial intelligence (AI)
An imprecise term that is generally used to describe the use of computer software to perform advanced functions that are associated with human intelligence.

Generative artificial intelligence
A category of AI associated with the creation of new, unseen data (such as images, text or video).

Machine learning (ML)
Generally considered to be a subset of AI. It refers to the use and development of systems that are able to learn patterns in data without being explicitly programmed.

Deep learning (DL)
A specific category of machine learning where the trained algorithm is based on a layered network architecture (see Artificial Neural Networks and Figure 3).

Artificial neuron
A simple mathematical function (Figure 1) that simulates a biological neuron. It has multiple weighted inputs summed to produce an output (Figure 2).

Artificial neuralnNetwork (ANN), neural nets, neural networks
A type of algorithm composed of a series of artificial neurons which are interlinked (see Figure 3). By linking together many neurons in layers, complex models can be built up. Input weightings are adjusted during training and the outputs compared to known values – the process is iterated until the difference in output value and known value is minimised.

Convolutional neural network (CNN)
A category of Neural Network that uses one or more convolutional filter layers. These algorithms are well suited to image-based problems

Large language model (LLM)
A loose category of deep learning models that are focused on language, with the ability to recognise, understand and generate text. These are trained on "large" datasets

Supervised learning
The act of training an algorithm to learn the relationship between input data and associated labels or response values. This procedure requires a training dataset to first be compiled, containing paired example inputs and 'ground truth' response values. For example, a training dataset could contain a series of medical images and associated binary classifications (normal/abnormal).

Unsupervised learning
The act of training an algorithm using input data or features only (with no associated label or response value). The algorithm can learn common patterns in the data but cannot be used alone to predict outputs.

combined with our increasing ability to diagnose and treat disease, mean humans in healthcare will not be put out of jobs. That's not to say the jobs themselves won't change as AI takes on routine tasks. More of a reviewer of the AI output, or job roles may shift e.g. more staff to curate and administer the AI systems rather than to do the clinical work. None of this is new – AI is a tool, a machine that does repetitive tasks instead of a human. We won't have idle nurses and doctors, but those doctors may spend less time writing up notes or reviewing images.

Regulations

Regulation of AI is needed to ensure it is safe, effective and equitable. AI is not specifically regulated at the moment in the UK, though the UK government recently launched a public consultation on what AI regulation might look like. (IPEM's Clinical Scientific Computing Special Interest Group Committee provided a response). AI systems that qualify as medical devices are regulated as such by the Medical Device Directives, requiring adherence to standards such as ISO 13485 (Quality Management for Medical Devices). Non-medical devices used in healthcare should follow Clinical Risk Management (DCB0129 and DCB0160). AI-specific regulations need to balance the desire for a "light touch" approach (so that we don't stifle innovations that could bring the benefits of AI to services and patients) against the potential burden of legal requirements to ensure AI is created safely and in line with good ethics. The "light touch" approach discussed in the consultation suggests manufacturers of AI software could essentially self-regulate. This could potentially be a conflict of interest, in that they have an interest in getting to market quickly with as little red tape as possible. The extant regulations around medical device software provide some level of assurance, but these regulations don't extend to the ethical considerations of data use. Other regulations do cover information governance and research governance, but this is a lot of regulation to be aware of. More so than with other medical device software, AI regulatory processes need to be open and transparent, with the public and patients being involved. But putting in an additional AI regulation further complicates the regulatory landscape for developers. Whatever regulations are in place need to be enforced, with the regulatory bodies requiring sufficient capacity to be able to deal with the number of AI systems and manufacturers that the regulations will apply to. Further complicating regulatory matters is that different regulations apply in different regions, with the EU specifically regulating AI in contrast to the UK's and US's currently non-specific approach.

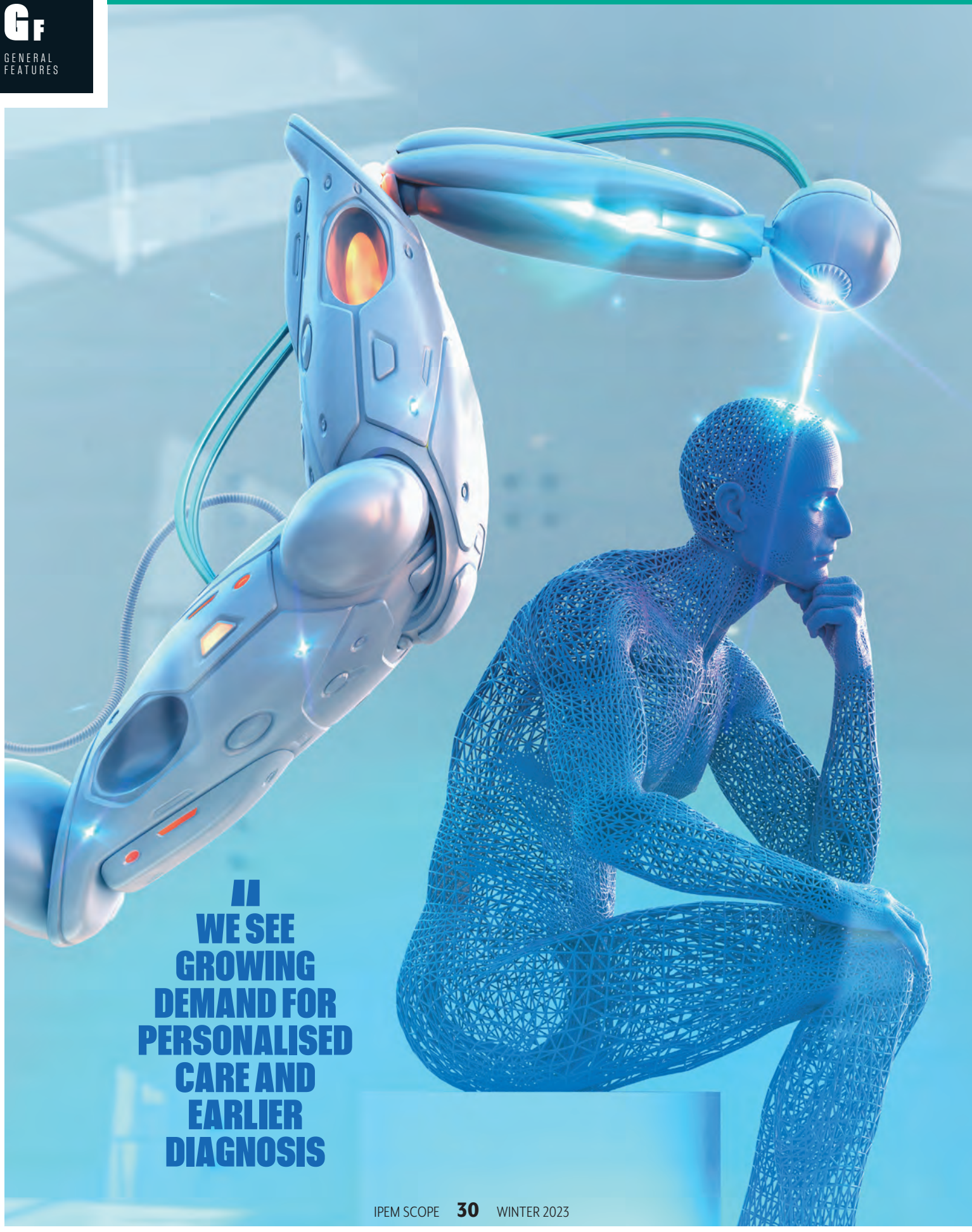
How this will be resolved will likely be an unending matter of debate with many valid points on both sides.

> **AI IS ALREADY HERE. ITS IMPACTS ARE ALREADY BEING FELT. LIKE ANY TOOL, IT BRINGS BENEFITS AND RISKS**

Summary

AI is already here. Its impacts are already being felt. Like any tool, it brings benefits and risks. In the next decade we will see increased healthcare use of it – in ways that might be largely invisible to most people. But as MPCE staff, we will likely be using AI for our research and quality assurance objectives, while clinical services will increasingly rely on it for automatic pathology detection, faster data acquisition, patient contact and many other areas. Our roles will evolve to increasingly support AI services. For me (and I admit to a bias here) this need for support further illustrates the need for Clinical and Scientific Computing departments within MPCE departments – perhaps we need to relabel this specialism as "Clinical and Scientific Computing and AI" and adjust our training programmes accordingly.

Dr Robert Ross *is Radiotherapy Physics Clinical Computing Lead in Radiotherapy Physics at Cheltenham General Hospital. If you are interested in contributing to this Scope series on AI in MPCE and healthcare, get in touch at robert.ross9@nhs.net. If you want to comment on or ask about anything in this article, start a discussion on IPEM's Clinical and Scientific Computing Community of Interest. ipem.ac.uk/get-involved/communities*



"WE SEE GROWING DEMAND FOR PERSONALISED CARE AND EARLIER DIAGNOSIS

EARLY CAREER ESSAY PRIZE 2023 WINNER

Helen Chamberlain looks at how the role of physics in the fight against cancer will develop over the next 10 years in this award-winning essay.

The application of physics in medicine has revolutionised our understanding and treatment of cancer. In the last 50 years, innovations in cancer care mean people are now twice as likely to survive for more than 10 years after diagnosis.

This progress is only expected to continue, meaning we are increasingly focused on living well after cancer, not simply survival. We are also facing a rapid increase in the number of people requiring cancer care, driven by increasing incidence and prevalence. Thus, demand on cancer services is only increasing at a time where global resources are being squeezed and scrutinised.

We also see a growing demand for more personalised care, earlier diagnosis, access to new treatments and techniques, as well as the need to address systematic inequalities. To discuss how the role of physics will change within this evolving cancer landscape, we need to consider what its role is now.

Physics is found at all stages of development in medicine; from concept, to research, to introduction of new equipment and techniques in the clinic, to maintenance and monitoring.

One key area of importance for physics in medicine is the use of radiation. This includes both ionising and non-ionising radiation and is used in both imaging and treatment. Physics is necessary for measurement, both of people themselves and equipment performance. This helps us diagnose problems, monitor safety and effectiveness, and manage risk.

Physics in medicine is also already highly multidisciplinary, with physicists involved in tasks from scientific problem solving, to radiobiology, to computing, as well as providing direct clinical support.

How will physics impact on cancer care in the next decade? Improving imaging means cancer can be diagnosed earlier, monitored better, and gives us more useful information. All these may enable more effective and targeted treatments. Within the next 10 years we are likely to see improvements in image quality driven by better equipment and software, as well as imaging systems that are faster and easier to use.

We also expect growing demand for safer imaging systems, with either lower radiation

IMAGES: GETTY

AN AWARD WINNING ESSAY

In September, Helen Chamberlain was awarded the 2023 IPEM/ Worshipful Company of Scientific Instrument Makers (WCSIM) Early Career Essay Prize for her essay entitled "How will the role of physics in the fight against cancer develop over the next 10 years?" Helen is an IPEM member who works as a Health Data Analyst for Macmillan Cancer Support. This involves analysis of large, diverse datasets related to patients, staff and UK health systems, enabling the charity to do whatever it takes to support those affected by cancer. She is also a Commissioning Editor for *Scope* magazine.

She has done work examining inequalities that impact those living with cancer and supported national campaigns. She is a member of the National Audit of Metastatic Breast Cancer Audit Advisory Committee. Helen previously trained as a medical physicist in the Northern Training Consortium, and worked as a Clinical Scientist in radiotherapy physics at The Christie, Manchester, specialising in treatment planning and brachytherapy.

Helen said: "I'm absolutely delighted to win the essay prize; thank you so much to both IPEM and WCSIM. I'm fascinated to see how the role of physics does develop in the next 10 years and I remain optimistic about the future of cancer care."

The award was launched in 2020 and is open to members of both organisations who are in the early stages of their career (typically within 10-15 years of graduation or of commencing their relevant employment).

doses or increased use of non-ionising options such as MRI. This may enable imaging to happen more often and possibly expand the scope of screening. Finally, improvements in computing mean we can get more information out of our images and automate more processes, such as using artificial intelligence (AI)-guided radiology reporting and contouring of anatomy.

Within cancer treatment, the diversity of treatment options is increasing, and many rely on fundamental physics concepts to deliver them safely and effectively. This includes the increased use of radiopharmaceuticals in therapies, as well as developments in radiotherapy. There is likely to be increased use of proton and heavy ion therapy and development of the next generation of radiotherapy treatment machines.

Therapies are likely to become more accurate and precise, which will hopefully increase effectiveness and reduce side effects. However, in turn this also means we are likely to see increasing numbers of people returning for multiple treatments over the course of years. This requires careful analysis of risk and benefit due to the potential for harm from excess radiation, and new strategies to increase patients' available treatment options in the future.

There is also an increasing demand to image during treatment, in order to provide the most accurate treatment possible. This will increasingly require physics staff to work across different traditional specialism boundaries.

More complex computing systems will also mean physicists must increasingly not only understand fundamental physics concepts, but also have a deep understanding of computers and how they model physical concepts. This ranges from automation in imaging and treatment planning using AI, to using machine learning and other "big data" tools to predict patient outcomes.

These tools have huge potential for speeding up treatment pathways, improving calculation accuracy and enabling increasingly personalised care based on better prediction of both risk and outcome from big data. However, they all need to be verified in the real world to check they are safe and accurate. Physics will therefore be necessary to decide on acceptable methods of verification and to problem solve where the results do not agree.

> **IMPROVEMENTS IN COMPUTING MEAN WE CAN GET MORE INFORMATION OUT OF OUR IMAGES**

Innovation is also needed in the next 10 years to better meet diverse needs. With increased demand we need systems that can perform more efficiently, as we need to be able to increase and improve services whilst tackling long waiting lists. With climate change we need systems that minimise their impact on the environment. With improved survival we need techniques that allow for longer term monitoring and retreatment. We need to be able to diagnose people faster and allow for increasingly personalised care, using data to ensure people get the best possible care. And we need to ensure we minimise inequalities in healthcare; ensuring our systems are fair, effective and accessible to all.

This means recognising how our current systems need to change to meet the needs of marginalised groups; from ensuring software can reflect LGBTQ+ identities, to ensuring technologies are equally effective on different skin tones, to ensuring we are aware of how biases propagate in datasets.

Overall physics is pivotal in shaping the future of cancer care. Not only is understanding of fundamental physics a requirement in modern cancer care, but the role of the medical physicist also means that they're well placed to support innovation, including advanced use of computers and new medical devices.

The role of physics is likely to become more important, with almost every cancer patient receiving some sort of scan or treatment that relies on physics, and physics will need to be used in increasingly multidisciplinary ways, at the interface of physics and biology, chemistry, and computing.

Without physics, it isn't possible to provide modern cancer care, let alone improve it.

Helen Chamberlain *is a Health Data Analyst for Macmillan Cancer Support*

Member profile:
Dr Emmanuel Akinluyi

I work as Deputy Chief Medical Officer, Chief Biomedical Engineer & Head of Clinical Engineering at Guy's & St Thomas' NHS Foundation Trust.

IMAGE: ISTOCK

Tell us about a typical work day.
My working days could be described as "consistently inconsistent". On a given day, I might spend time working directly on medium- to long-term projects that could involve platform development, policy development, technology adoption projects or risk assessments, or I might be working towards other strategic developments in technology management. I might also chair or contribute to one of our working groups and committees, or engage externally with networks, and some time inevitably goes towards responding to change and matters arising.

Which elements of your job do you like the most?
I love that my job involves overcoming challenges and problem solving – especially when we get to do this on the front foot and drive some form of transformation. I also enjoy working with committed and talented people.

What are the biggest challenges for yourself or the sector?
I think one of the challenges we have as clinical engineers is understanding where we should start, or where we should be directing our efforts.

What one thing would you like to change about the profession or your area of specialty?
I'd like to see more clinical engineers with more visibility, offering more services to improving and sustaining care. I really believe in the potential for this profession (and others) to affect change, and I think that there is huge potential to do more and do it better.

What accomplishment have you been most proud of in your career?
I'm really proud of the growth of my team over the last few years. We have developed our service around a strategy to maximise value delivered with medical technology.

What are your predictions about the future of your profession and your area of specialty?
I think and hope we will see growth and reshaping of services to meet the needs of the health service. Clinical engineers will need to adapt how we do things to meet growing demands, and adapt what we do to meet changing demands. We will have a greater role in shaping change and in improving technology-enabled services.

What do you do in your free time?
I love to spend time with my family and to stay active with outings and cycling trips. I am also involved at my local church, where, among other things, I play the bass guitar in the band.

Why did you join IPEM?
I became aware of IPEM while searching for what I eventually came to know as the Scientist Training Programme. IPEM and its members played a crucial role in shaping the career path I've progressed along. I joined IPEM on reaching the milestone of being registered as a Clinical Scientist. It has been a great opportunity to participate in providing similar opportunities for others.

How do you engage with IPEM?
I have attended and contributed to several IPEM conferences, meetings (arranged by the Clinical Engineering Specialist Interest Group) and outreach events. I contribute to an MSc programme that IPEM accredits and I received an early career award and a travel award, many years ago.

Which IPEM member benefits do you value or use the most?
Conferences and any networking opportunity.

What does (or should) IPEM do to help you in your career?
IPEM provides access to a network of engaged colleagues in my specialism and beyond. I really value conferences, meetings and other opportunities to share ideas. I have noticed IPEM uses social media platforms to encourage and promote the work of its members – I think this has been very effective.

METHODS AND APPROACHES TO PATIENT DOSE AUDITS

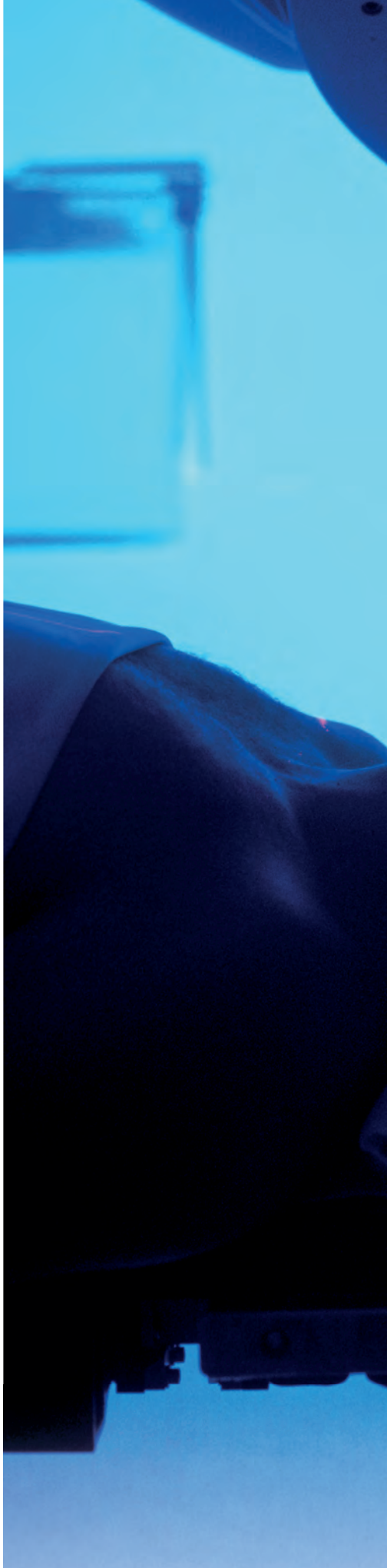
A 2023 snapshot

A team of Clinical Scientists from Radiation Protection Services at University Hospitals Birmingham NHS Foundation Trust report back on the results of a survey.

The *Ionising Radiation (Medical Exposure) Regulations 2017 (IRMER17)* require employers to establish and review diagnostic reference levels (DRLs) for radiodiagnostic examinations. It is therefore part of the work of radiation safety and diagnostic radiology departments like ours to carry out regular patient dosimetry (PD) audits for examinations using X-rays.

PD audits help us track patient dose metrics, such as dose area product (DAP), for general X-ray and dose length product (DLP) for computed tomography (CT), for specific rooms and examinations over time. They are compared to local and national DRLs (LDRLs and NDRLs, respectively) to help us ensure imaging departments operate within the range of good and normal practice. Additional benefits have been found locally over time, including finding and correcting inconsistencies in protocols between rooms.

Almost 20 years ago, *IPEM Report 88* was published, providing guidance on how to conduct PD audits, set LDRLs and decide if an LDRL is consistently exceeded. Since then, there have been several reviews of NDRLs, with the latest available NDRLs and techniques used to set them referenced on the gov.uk website. Local practices have also developed to take advantage of the information and analysis tools available, such as radiological information systems (RIS) and, more



"WE DEVELOPED A SURVEY TO CAPTURE INFORMATION ON CURRENT PRACTICES AROUND THE UK"

IMAGES: SCIENCE PHOTO LIBRARY/ALAMY

Table ❶ Questions asked in the survey, split into broad themes.

Theme	Questions asked
General data collection	● Where do you collect your data from when performing patient dose audit? ● For a given modality (e.g. planar x-ray, CT fluoroscopy), how often do you perform routine patient dose audit? ● What numbers of patients to you require for an examination to be included in a patient dose audit?
Data processing	● How do you define the average dose for an examination in a given room? ● Do you use any processing on the data to discard some individual doses from the analysis? E.g. to remove based on weight or doses which appear to be outliers. ● How do you define the average of room doses for a given examination (referred to as "mean of means" in *IPEM 88*)?
Exceeded LDRLs	● How do you set LDRLs for examinations based on your patient dose audit? ● How do you decide if an LDRL has been consistently exceeded?

recently, dose management systems (DMS). We also understand that a review of *IPEM 88* is underway, which will bring welcome updated guidance on this process.

All these considerations caused us to reflect on our own practices, which have developed over time. Questions arose over what an appropriate frequency for PD audit is, especially considering currently increasing workloads. Are we consistent with what other centres are doing? Are we making best use of the systems available to us? As a large centre providing services for many healthcare organisations, it is a great challenge to successfully implement a DMS we can use consistently. Are we alone in this?

To find answers, we developed a survey to capture information on current practices around the UK, which was posted to the Medical Physics & Engineering jiscmail list. Our survey captured information on general approaches to starting a PD audit, processing of the data and deciding if an LDRL has been consistently exceeded. Respondents were asked to focus mainly on more routine PD audits, such as general X-ray, fluoroscopy and CT. More complex audits, such as interventional radiology and hybrid imaging (e.g. nuclear medicine CT) were excluded as they can be particularly challenging, requiring specific solutions. The full list of questions is shown in table ❶.

Findings of the survey

General data collection

We received responses from 33 centres across the UK. 55% of respondents used a single source of data for all PD audits. In that group, just under 60% source data

from radiological information systems such as CRIS. This is followed by a DMS, which was used in one-third of cases, which means only 18% of respondents took all their data solely from a DMS (i.e. a third of the 55% of respondents who use a single data source). Overall, 62% of respondents were using DMS sourced data, but of those 71% used another data source alongside the DMS.

Figure ❶ shows the results for frequency of PD audit. Comments from respondents showed that PD audits were performed more frequently for CT and mammography than other modalities. These centres are likely prioritising CT as it is a higher dose modality. For mammography, this may be because SQAS (the arm of UKHSA which manages the quality framework within the NHS breast screening programme) promotes annual dose audits as best practice. A few reported that they were taking a graded approach to PD audit, with more frequent review for LDRL compliance, and a "full" audit with potential of re-setting of LDRLs being done less often.

There was variation in the minimum number of patients per examination to be included in the audit ❷. *IPEM 88* recommends a minimum of 10 (adults), which was satisfied by all. Most centres required between 10 and 50 patients, whilst a few rejected any with less than 50.

Only 15% of respondents specifically mentioned using patient weight as a criterion for inclusion, which likely reflects the difficulty in obtaining this data (our experience is that patient weight is not routinely recorded at time of examination and even if weight data were acquired from elsewhere in a patient's record, it is unlikely to be contemporaneous). Most of those who excluded dose data based on weight did so using manual data collection. Some cited the lack of weight information as a rationale for using a higher minimum number for inclusion. Others were taking an ad-hoc approach to the minimum number, depending on the quality of data, modality and examination type.

Data processing

The vast majority of respondents (almost 80%) define the average dose of an examination for a given room as the median as opposed to means or other methods (approximately 10% each).

Question 5 (on data processing for outlier removal) gave some of the most varied responses on the survey. Approximately 70% of respondents used some sort of outlier removal. Of the remaining 30% who do not, almost all define averages using medians and so it can be assumed they deem outlier removal unnecessary because the median is less skewed by them.

Many outlier removal methods are in use – including manual judgement of the data points. The most consistently used method (used by 12% of respondents) was to remove the upper and lower (in terms of dose metric) 5% of datapoints from the analysis. Users of this method referred to recommendations in *ICRP 135*. Some other centres use variations on this method e.g. removing the upper/lower 10% or 20% of datapoints.

"ONLY 15% SPECIFICALLY MENTIONED USING PATIENT WEIGHT AS A CRITERION FOR INCLUSION

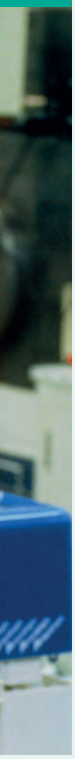
We could not identify any more consistently used approaches, so will restrict ourselves to mentioning these few examples of the data processing being used to deal with outliers in the data. The key point we noted is that there is no consistent approach as local centres have developed their own solutions.

When defining the average of room averages, there is also some variation in approach, as shown in figure ❸.

The centres which used means to define average in question 4 used the mean of means to define average of room doses, which is the approach suggested in *IPEM 88*. Of the remaining centres, approximately 6% use the median of all data points to define this value. But the majority of respondents (75%) use either the mean of medians or median of medians, with approximate equal split between these two methods.

Exceeded LDRLs

IPEM 88 suggested method of setting an LDRL for a particular exam type is to take the mean of room means. Figure ❹ shows how approximately 65% of respondents reflect this approach in using some definition of "average of averages". Various other approaches were also taken, often based on a median of third quartile of the entire dataset.



IPEM 88's test of an LDRL being exceeded in any particular room is when the room mean exceeds the LDRL by over 20% and by more than twice the standard error on the mean (SEM). Half the survey respondents reported using this method. Some commented that 2*SEM was no longer an appropriate criterion as they were using medians instead of means, so they used the 20% criteria alone. Others reported exceed criteria including: room mean above LDRL (no further threshold applied), 3*SEM, and a range of other statistical tests.

Conclusions

The results of this survey show more than half of the respondents use a DMS in some way, indicating that they have become widespread but a significant number of centres do not yet own or implement them. Where they are in place, a DMS is not always fully utilised as the majority use them in conjunction with another data source (only 18% of respondents use a DMS as their sole source of data). This is perhaps an unexpected finding given the commercial and scientific attention given them in recent years. We did not ask respondents to explain the rationale for their chosen data sources, but from our own experience we speculate that this is due to the complexities of fully implementing a DMS in large organisations and for centres which provide diagnostic radiology physics services to multiple healthcare organisations. This may also explain another unexpected finding that DMS users do not appear to carry out PD audits more frequently than organisations that do not use a DMS.

Our survey also reveals that there is much national inconsistency and departure from the techniques recommended in *IPEM 88* in certain areas of the PD audit process. The most variable parts of the process appear to be in data processing to remove outliers and the definition of average of average dose metrics across imaging rooms. This perhaps shows that *IPEM 88* has become outdated, or at least practice has moved on and centres have found their own local solutions. This makes the upcoming review of *IPEM 88* most welcome.

As a follow-up to this work, we plan to more quantitatively analyse some of the PD audit techniques identified in this survey to find out how much this may contribute to variations in LDRLs set at different centres across the UK.

Jade Clarke, Matthew Gardner, Michael Katsidzira, Elizabeth Larkin, Peter McGookin and William Newman *are Clinical Scientists, based at the Radiation Protection Services, University Hospitals Birmingham NHS Foundation Trust.*

Figure ❶ Frequency of PD audits

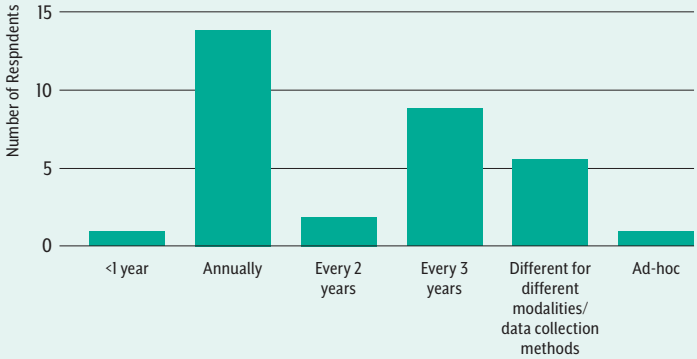


Figure ❷ Number of patients required to proceed with a PD audit

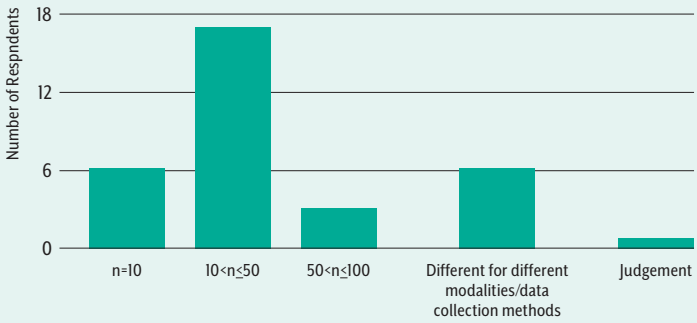


Figure ❸ Definitions of the average of room averages

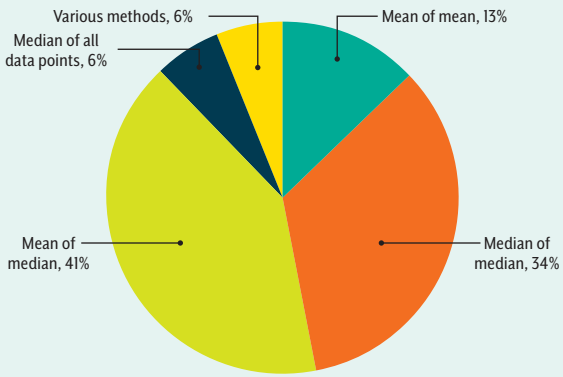
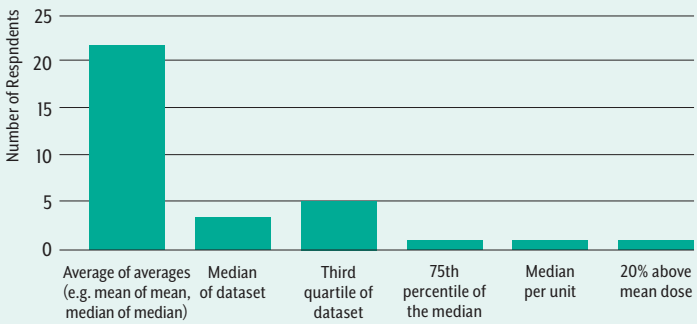


Figure ❹ Methods of setting LDRLs



Eduard Gershkevitsh and colleagues from the North Estonia Medical Centre look at the advanced treatment planning process for prostate cancer.

AI-AUTOMATED RADIOTHERAPY

Relatively simple target shapes, dose prescription standardisation and the number of patients requiring radiotherapy make prostate cancer radiotherapy treatment planning a first choice for the implementation of artificial intelligence (AI) and automated treatment planning. By using an AI-driven automated treatment planning approach, one could reduce planning time for dosimetrists and medical physicists, while improving treatment plan consistency.

AI models

Two separate commercially available AI solutions were used for contouring and planning. For automatic contour delineation the AI-based autocontouring software Contour+ (MVision OY, Helsinki) was used. The model is based on proprietary guideline-based segmentation (GBS) algorithm to delineate organ at risk (rectum, bladder, femoral heads) and target (prostate and seminal vesicles) structures. While the user can create their own segmentation model, a previous study demonstrated the usability of a general model across multiple institutions. As a start, a number of structures are created. PTV60 (3 Gy/fraction, 20 fraction) is automatically created by adding 5 mm margins to the target. Rectum and bladder walls are derived from rectum and bladder structures. Fiducial markers are automatically outlined and used for image-guided radiation therapy (IGRT) set-up of the patient on the Linac. These marker structures are used during treatment: intrafractional imaging is used for all patients, whereby 2D planar images are acquired with every 60° gantry movement, during volumetric modulated arc therapy (VMAT) delivery, and compared to digitally reconstructed radiography (DRR). A positioning tolerance of 3 mm is used to pause the beam.

For radiotherapy treatment planning RayStation 12A (RaySearch Laboratories AB, Stockholm) TPS was used for autoplan generation. AI model generation is completed by the vendor, based either on an existing or a newly trained model. Both approaches have advantages and disadvantages. Use of an existing model requires less patient data and time to produce. This could serve as an independent benchmark for treatment planning practice. The disadvantage is the inability to take into account departmental variations (should there be any). We have used the existing AI model, created by Princess Margaret Hospital in Toronto, and incorporated our own departmental clinical goals and DVH parameters.

Model validation process

The autosegmentation model was initially tested for contouring accuracy and time efficiency on 37 patients, by comparing manually contoured structures to automatically segmented structures using autocontouring software. StructSure software (Standard Imaging Inc., Middleton) was used to evaluate the difference in structure volumes and Dice similarity coefficient, while the time taken to manually outline and to modify autosegmented contours was recorded.

Six local treatment plans were selected for fine-tuning of the existing planning model, while 10 patient treatment plans were selected for model validation. For all patients, autoplans were compared to manually created plans. The second stage involved the prospective planning comparison. First, the dosimetrist or medical physicist created a manual plan, which took on average 1.5 hours. After, an automated plan was generated, which took on average 5 min (no human involvement). Both plans were presented to two radiation oncologists who scored the plans and provided feedback,

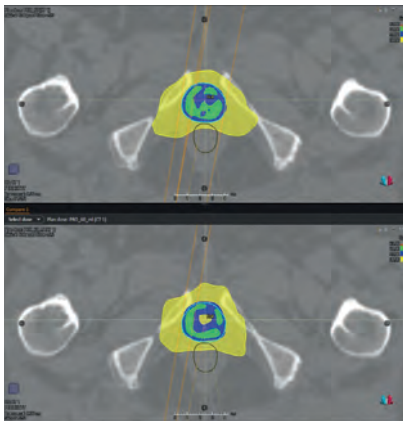
without prior knowledge of which plan is which. This process was conducted for 30 prospective prostate cancer patient treatment plans.

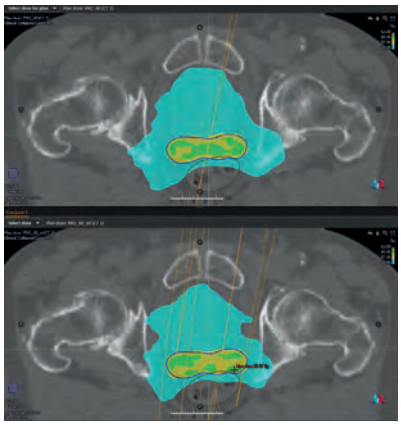
Results

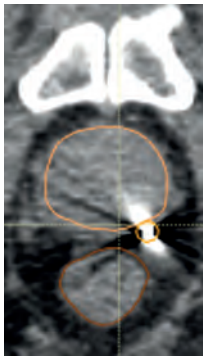
The results of autocontouring are always reviewed, and modified if necessary, by the experienced radiotherapy technologist prior to the start of the autoplanning process. The implementation of autocontouring has allowed for the reduction in contouring time, by on average 67%. The Dice similarity coefficient ranged from 0.64 (seminal vesicles) to 0.92 (bladder), with the majority of structures above 0.80.

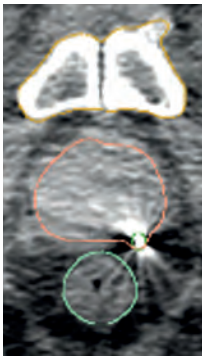
While most of the autoplans meet the departmental clinical goals and DVH criteria in the retrospective plan comparison series, only about 25% of the autoplans were chosen in the prospective series by the radiation oncologists, typically due to poorer PTV coverage and higher bladder doses. There were at least two reasons why the AI model in prospective analyses performed worse than expected from retrospective analyses. In the prospective planning phase, the results of both (manually created and automated plans) were seen by the dosimetrist and medical physicists. This impacted the manual planning process by increasing the planning time to 2-2.5 hours, as the planner tried to beat the autoplanning. So, the manual plans started to become better than those retrospective plans used for model initial fine-tuning, particularly for low to intermediate doses to the rectum and target coverage. The second reason was related to the plan evaluation process performed by the radiation oncologists, which did not rely only on clinical goals and DVHs when judging the plans, but also on isodose distribution. Figure ❶ shows examples where the autoplan was deemed inferior to the manually created plan.

Based on this feedback, five more iterations of the model were made to improve the results. At the moment, around 60% of selected plans are autoplans. The departmental workflow now is to start with the autoplan first and then evaluate. If it does not meet the criteria and acceptance by the radiation oncologist, the planner should proceed with a manual plan. No statistically significant differences were observed in plan complexity (number of CP, MU, complexity index) and patient specific QA results between manually created and autoplans.









Above: Figure ❶ Comparison of autoplan (bottom) and manually created plan (top). Left images show cold spot in the apex of the prostate for autoplan. Right images show hot spot in seminal vesicles close to rectum wall. Both were listed as reasons for not selecting autoplan.

Left: Figure ❷ Comparison of manual delineation (left image) and autocontouring (right image) of prostate and fiducial marker.

Final remarks

- AI autocontouring allows time reduction and improves contour consistency.
- AI driven treatment planning can improve the overall plan quality, minimise interplanner plan quality variability and saves time.
- Currently-used plan quality metrics (DVH) are not sufficient to explicitly express the desires of the radiation oncologists.
- In about 25% of the cases manual planning produced significant better treatment plans than autoplan, indicating the model deficiencies.
- There are a limitations in current AI models, for both autocontouring and autoplanning, even for relatively simple clinical cases such as prostate.
- The limitations of the models need to be addressed to improve the results. One limitation of autocontoring model used is shown on Figure ❷, which depicts the case where one fiducial marker was placed extracapsularly. The AI model included it into the prostate as this is the situation with its training dataset, with all the fiducial markers inside the prostate. ○

Eduard Gershkevitsh *is Head of the Medical Physics Service,* ***Anni Borkvel*** *is a Dosimetrist,* ***Daniil Zolotuhhin*** *and* ***Jelena Gershkevitsh*** *are Medical Physicists,* ***Merve Adamson*** *and* ***Kati Kolk*** *are Radiotherapy Technologists and* ***Dr Indrek Oro*** *and* ***Dr Mikk Saretok*** *are Radiation Oncologists. All are based at the North Estonia Medical Centre in Tallinn, Estonia.*

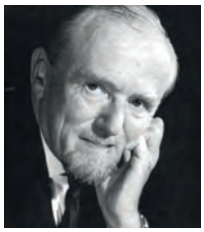
60 YEARS

International Organization for Medical Physics

Slavik Tabakov, Chair of the International Organization for Medical Physics' History Sub-Committee and previous President, looks back over the organisation's remarkable history.

This year the International Organization for Medical Physics (IOMP) celebrates 60 years since its establishment. Now IOMP is the umbrella of the medical physics societies from 90 countries with about 30,000 members. The mission of IOMP is to advance medical physics practice worldwide by disseminating scientific and technical information, fostering the educational and professional development of medical physicists,and promoting the highest quality medical services for patients. A very important aim of IOMP is to address the uneven distribution of medical physicists around the world, especially supporting low- and middle-income (LMI) countries. While in Europe and North America there are currently a minimum of 12 medical physicists per million population (over 30 in the UK), in the rest of the world the figure is about two medical physicists per million (about 0.5 in Africa).

This year, the International Day of Medical Physics (IDMP), which took place on 7 November, was dedicated to this anniversary under the logo "IOMP's 60th Anniversary: Standing on the Shoulders of Giants" – celebrating colleagues who contributed to the scientific achievements and to the professional development of medical physics.



❶ Val Mayneord
IOMP President 1965–1969

❷ John Mallard
IOMP President 1979–1982

❸ Keith Boddy
IOMP President 1994–1997

Since its establishment, IOMP has been led by 20 Presidents. Nine of those were from Europe, including four from the UK. Medical physicists from IPEM had very important contributions in the establishment and development of the IOMP over these 60 years. This article summarises some of these main contributions.

Leadership

During 1950s, medical physicists were mainly in the large developed countries and a number of meetings were held aiming to create an international organisation focussed on the global development of the profession. IOMP was formally established at the beginning of 1963 with four founding members – the societies from UK, Sweden, the US and Canada. The first acting leaders of the organisation were: S. Benner (President, Sweden), LF Lamerton (Vice-President, UK), JR Mallard (Secretary-General, UK). The first elected President of the IOMP was from the UK – Val Mayneord (1902–1988). He held this top position of IOMP in the term of office 1965–1969. In his term were initiated the International Conferences on Medical Physics (ICMP), the first one being held in Harrogate in the UK in September 1965. This ICMP gathered about 500 medical physicists from 24 countries and laid the foundation of regular ICMPs over the years. The 20th ICMP was held together with IPEM and EFOMP in Brighton, UK, (September, 2013), celebrating the 50th anniversary of IOMP.

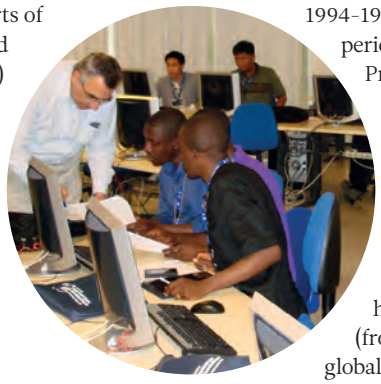
The next IOMP President from the UK was John Mallard (1927–1921). He held the office in the period 1979–1982 and was one of the most important leaders of the organisation. During his leadership IOMP began the establishment of its Regional Organisations (Federations), which coordinate the professional activities in the continents. The first one was EFOMP (the European Federation of Organisations for Medical Physics), established in 1980. John Mallard also played a very important role in the establishment of the International Union of Physical and Engineering Sciences in Medicine (IUPESM), established also in 1980 (with him as inaugural President).

The union combined the global efforts of medical physicists (through IOMP) and biomedical engineers (through IFMBE)

in order to achieve membership to the International Council of Scientific Unions (ICSU, now ICS). This was very important for the recognition of our scientific fields as unique branches of science. In 1982 ICSU accepted IUPESM as an Associate member, thus initiating the long process of recognition, which in the future years resulted in the opening of many new university courses in medical physics. This was the first major international achievement of the IOMP and IUPESM and, to acknowledge the enormous contribution of John Mallard for this, IOMP established in 2016 a special international award named after him.

Major achievements

The third IOMP President from the UK was Keith Boddy (1937–2010). He held the IOMP Office in the period 1994–1997 and in this period, plus the next period (1997–2000, when he was IUPESM President), he focussed on the ICSU Full membership. Active role in this process had also Gary Fullerton and Dov Jaron (US). The Full membership was achieved in 1999, which really opened the gate for the global development of the profession: while between 1965 and 1995 the profession had an overall growth of c.6,000 (from 6,000 to 12,000) medical physicists globally, in the next 20 years 1995–2015 it



"FULL ICSU MEMBERSHIP OPENED THE GATE FOR THE GLOBAL DEVELOPMENT OF THE PROFESSION

IMAGES: GETTY/SCIENCE PHOTO LIBRARY

had a growth of c.12,000 (from 12,000 to 24,000). Many new MSc courses in medical physics were opened around the world. The author personally supported the establishment of 15 MSc courses in LMI countries.

The next very important step for IOMP and IUPESM was the membership to the International Labour Organisation (ILO), what was aiming at international recognition of the professional occupations "medical physicist" and "biomedical engineer" – an activity very important for the establishment of training and certification schemes and the employment of thousands of medical physicists around the world. Leading role in this process had the IOMP Officers Azam Niroomand-Rad (USA), Fridjof Nuesslin (Germany), Peter Smith (UK) and S Tabakov (UK). This major achievement was announced in 2012 and both professional occupations were included in the International Standard Classification of Occupations (ISCO). To celebrate this achievement, especially important for the LMIC countries, IOMP launched in 2013 the International Day of Medical Physics (IDMP).

The fourth IOMP President from the UK was Slavik Tabakov. He held the IOMP Office in the period 2015–2018. He continued the IOMP activities in supporting professional growth and education in LMI countries, coordinating the development of various e-learning resources, including *e-Encyclopaedia of Medical Physics* with *e-Dictionary of terms* (translated into 31 languages). He established with P Sprawls the

IOMP e-journal *Medical Physics International* (MPI), dedicated to education and professional development, a journal read by thousands every month. With Steve Keevil and Sally Hawking, in 2017 he arranged the legal status of IOMP through incorporation of the organisation in the UK (hosted by IPEM). The experience from this important IOMP activity was used in 2021–2022 by the same team, additionally with Leandro Pecchia and Fiona McKeown, for the incorporation of the IUPESM (also hosted by IPEM).

"IOMP CONTINUES ITS ACTIVITIES FOR GLOBAL DEVELOPMENT OF MEDICAL PHYSICS

Most remarkable

The achievements of the IOMP over these 60 years are most remarkable in the LMI countries. The global progress of the profession is seen well in the series of papers (per continent), which *MPI* journal commissioned and published in the period 2019–2022. As an example, when the African Federation FAMPO was formed in 2009, there were about 300 medical physicists on the continent and by 2020 the number grew to about 1100 (now supported by their own *African Journal of Medical Physics*).

Currently IOMP has eight committees and six sub-committees and boards. During each three-annual office in the past 20 years IOMP activities have been served (on a voluntary basis) by about 100 committee members from various countries. IOMP continues its activities for the global development of medical physics aiming to reach the predicted global need of about 60,000 specialists by 2035.

Slavik Tabakov *is an IPEM Fellow and Chair of the IOMP History Sub-Committee, the IOMP President 2015-2018 and Emeritus President at IUPESM. For information on IOMP, visit iomp.org*

SYSTEM INTEGRATION

Past, present and future

Senior Radiation Engineer **Mohamed Madani** looks at the integration of oncology information systems and hospital information systems.

The history of integrating hospital information systems (HISs) for oncology information systems (OISs) reflects the broader evolution of healthcare technology and the increasing need for specialised solutions in oncology care. The adoption of hospital information systems began in the 1960s and 1970s, primarily focused on administrative functions, such as patient registration, billing and inventory management. However, oncology-specific record keeping and verification functionalities were not yet established during this period.

Clinical information systems

Later, by the 1980s and 1990s, clinical information systems (CISs) started to gain traction. These systems aimed to capture and manage clinical data, including oncology-related information. CIS solutions began incorporating modules specific to oncology, such as tumour registries, chemotherapy administration records, and treatment planning. As oncology care advanced and became more specialised, dedicated OISs were developed. They provided comprehensive functionality for oncology record and verification, including features such as oncology treatment planning, chemotherapy management, radiation therapy documentation, tumour board coordination and outcomes reporting. With the growing need for seamless data exchange and interoperability between oncology-specific systems and general hospital information system, integration efforts intensified.

Integration interfaces

In the late 1990s and early 2000s, integration interfaces were developed to enable the exchange of oncology data between different modules within the hospital information system infrastructure, such as electronic health records (EHRs), billing systems and laboratory systems. The establishment of interoperability standards played a significant role in facilitating integration between oncology systems and general HIS. Standards such as Health Level 7 (HL7) and Integrating the Healthcare Enterprise (IHE) provided guidelines and frameworks for exchanging oncology-specific data, such as pathology reports, treatment plans and radiology images, between different healthcare applications. Oncology care relies heavily on imaging technologies, such as computed tomography (CT), magnetic resonance imaging (MRI), and positron emission tomography (PET). Integration efforts focused on incorporating oncology imaging systems, such as picture archiving and communication systems (PACS), with HIS to ensure seamless access to imaging data within the oncology record and verification process.

Improve interoperability

Recent years have seen increased efforts to improve interoperability and data exchange in healthcare, including oncology care. Standards like Fast Healthcare Interoperability Resources (FHIR) are used to facilitate the exchange of information between different systems and applications involved in cancer care and gained prominence, enabling easier integration and sharing of oncology data

between different systems and platforms. FHIR have facilitated secure data exchange, enabling the development of innovative oncology solutions and promoting collaborative care. The integration of HIS for OIS continues to evolve as healthcare technology advances. The focus remains on achieving seamless interoperability, comprehensive oncology data management, and improved patient outcomes through integrated OISs. The integration between OISs with a HISs offers numerous benefits for healthcare organisations, clinicians, and patients, such as comprehensive patient information, streamlined workflows, enhanced care coordination, improved patient safety, data-driven decision-making and patient engagement and empowerment can enable the patient to access to their oncology records through patient portals or mobile applications. Overall, the integration between OIS and the HIS is essential for optimising oncology care delivery, improving clinical outcomes, and enhancing operational efficiency in healthcare organisations.

IMAGE: SHUTTERSTOCK

RECENT YEARS HAVE SEEN INCREASED EFFORTS TO IMPROVE INTEROPERABILITY

What next?

The future of HISs and OISs holds several exciting directions and innovations, for example artificial intelligence (AI) and machine learning (ML), predictive analytics and population health management and integration of genomic and molecular data. These future directions and innovations aim to optimise oncology care delivery, enhance patient outcomes, enable personalised medicine and support data-driven decision making in healthcare.

The precise implementation and timelines for these advancements will depend on technological developments, regulatory considerations and healthcare industry trends.

While HISs and OISs have made significant advancements, several challenges rely on both systems, due to high levels of complexity, as there are various modules and integration areas to be addressed, such as achieving seamless interoperability between different HIS components, as well as between HIS and external systems, remains a challenge. Systems often use different data formats, coding standards and communication protocols, leading to data fragmentation and difficulties in exchanging information. Standardisation efforts, such as the adoption of interoperability standards, such as HL7 and FHIR, are ongoing but require widespread implementation to ensure effective data sharing.

Aggregating data from various sources within the HIS and integrating it with the oncology information system can be complex. Inconsistent data formats, data entry errors, and data discrepancies between systems can impact the accuracy and reliability of the integrated data. Protecting patient data from breaches and unauthorised access is a significant concern. HISs and OISs store sensitive patient information, making them potential targets for cyberattacks. Implementing robust security measures, including encryption, access controls, and regular security audits, is essential to safeguard patient privacy and maintain data security.

Addressing these challenges requires collaboration among healthcare organisations, technology vendors, policymakers and regulatory bodies. Continuous innovation, stakeholder engagement, and a commitment to user-centred design principles will play a crucial role in overcoming these challenges and unlocking the full potential of HIS and oncology information systems.

Mohamed Madani *is a Senior Radiation Engineer at the Physics Engineering, Kent Oncology Centre, Maidstone and Tunbridge Wells NHS Trust*

IPEM ACCREDITATION

"Flexible and valuable"

IPEM accreditation of degree programmes gives Higher Education Institutions (HEIs), employers and prospective students confidence that courses meet the expected quality and learning outcomes required for a career in medical physics or clinical engineering. Here, **Lauren Harrison**, IPEM's Training Manager, explains the process.

IPEM is dedicated to developing the next generation of medical physicists and clinical engineers and completing a relevant degree supports students with meeting the educational requirements for some routes into the profession. IPEM currently accredits master's level programmes under the Masters Level Accreditation Framework (MLAF) and has also developed the Undergraduate Level Accreditation Framework (ULAF). IPEM is also licensed by the Engineering Council to accredit undergraduate and integrated master's courses alongside other Professional Engineering Institutions (PEIs). Accreditation of these engineering programmes demonstrates that they meet, or partially meet, the educational criteria for registration as an Incorporated Engineer or a Chartered Engineer.

IPEM accreditation is carried out by volunteers working in a range of roles, including experienced academics, and medical physicists and clinical engineers employed in healthcare and industry, ensuring that best practice across all areas is inputted into the courses.

Dr Mark McJury, Consultant Clinical Scientist and secretary of IPEM's Course Accreditation Committee, said: "MLAF is relevant to HEI courses for those progressing to careers in healthcare, industry and academia, and the framework has evolved to take account of the increasingly diverse educational background of students on contemporary Masters courses. The MLAF's structure of Intended Learning Outcomes assessment has the flexibility to allow MSc courses to include specialist modules and variable degree titles."

Annual prizes

Programmes awarded full IPEM accreditation are given a Certificate of Accreditation and are provided with the IPEM Accredited logo, which they can use on promotional material and documentation as well as being listed and promoted by IPEM. The Institute also awards an annual prize for the best student project on each IPEM accredited MSc.

Emily Kilgour, an IPEM Student Prize award winner, said: "Studying at the University of Aberdeen for the IPEM-accredited MSc gave me a strong academic foundation for my training towards Clinical Scientist registration on the Scottish Medical Physics Training Programme. The course provided a good grounding in the theory of the areas within medical physics and gave students the opportunity to visit some of the

departments to see what they were learning put into practice. As part of the MSc, I undertook a clinical research project investigating the accuracy and reproducibility of apparent diffusion coefficients in MRI. It was exciting to be part of research in a topic of current clinical interest and I was able to continue working on this project into my clinical training."

Mme Ubong Esien, another IPEM Student Prize award winner, added: "Pursuing a career in medical physics has always been my passion. To fulfil this dream, I enrolled in the MSc programme in Medical Radiation Physics at Swansea University, which is accredited by IPEM. This programme provided me with an exceptional opportunity to gain profound insights into the application of radiation in human medicine. More so, the benefit of support from the faculty and staff of Swansea University made my learning experience unforgettable. Receiving the IPEM prize for best dissertation was an honour, attesting to my excellent research skills. This recognition adds significant value to my academic journey and enhances prospects for further research in the field of medical physics. Having completed the programme, I look forward to completing a PhD and an exciting career in clinical science and research.'

IMAGES: ISTOCK

Supported throughout

Universities seeking IPEM accreditation through MLAF and ULAF are supported throughout the accreditation process and can also seek provisional accreditation from IPEM. In 2022, the University of Oxford was the first university to be granted provisional accreditation for their MSc in Medical Physics with Radiobiology.

Course Director, Dr Daniel McGowan, said: "Having a list of IPEM learning outcomes in the framework was really helpful when I was planning out the new MSc and setting learning outcomes for each module. I used many of the exact IPEM outcomes, which made the job of the IPEM assessors easier as well as my job in designing learning outcomes.

"IT IS CLEARLY SOMETHING OF BENEFIT TO POTENTIAL STUDENTS

"It is helpful that within the IPEM framework you still have a large amount of flexibility to have your own HEI specialist modules, in our case we focused on radiobiology and have also incorporated some clinical trials and artificial intelligence teaching.

"It was helpful being able to tell university committees reviewing our application that we had this external accreditation underway and show the feedback that we had been given.

"Applicants have mentioned our provisional IPEM accreditation in their applications so it is clearly something of benefit to potential students, and we look forward to applying for full accreditation once our first cohort finishes next year."

Find out more

You can find out more about IPEM accreditation and view the full list of accredited programmes by visiting the link **ipem.ac.uk/learn/ipem-academic-accreditation-and-course-approval**.

IPEM would like to thank all of its volunteers who make up the Course Accreditation Committee (CAC), the Engineering Course Accreditation Panel (ECAP) and the assessors for all of its accreditation activity.

EXPLORING THE FUTURE

An IPEM leadership event

The future of the profession was under the microscope at an event that explored potential challenges in the years to come.

More than 60 IPEM members came together for a Science Leadership Day that explored the future of medical physics and clinical engineering.

The day was held to examine an array of potential futures for the sector and look at how IPEM can drive the profession forward and support members.

It came on the back of IPEM's *Science Leadership Strategy* (see box, right), which identified three "grand challenges" – external factors which will heavily influence the operating environment: climate change, staffing and workforce and safety and security.

The volunteers assembled at the meeting, which was held on 29 September in York, had to work with four different potential futures and find IPEM actions that would be a success across all scenarios.

Professional interventions

The four imagined futures, which were set 30–40 years in the future, covered a range of political and ideological possibilities.

They ranged from a future in which there is progressivism and citizen involvement in society with consumerism critiqued and climate change a priority, to a world in which nationalism and protectionism are centre stage and consumerism reigns with an emphasis on economic growth.

Those taking part in the event broke up into smaller groups and following a number of brainstorming exercises had to present their ideas for professional interventions that would work in the future scenarios.

The actions that the groups came up with covered a variety of areas, but among the most prominent themes were lobbying, professional development, networking and collaboration.

Training, diversity, green strategies and horizon scanning were also popular themes.

Practical future outcomes

Philip Morgan, IPEM's Chief Executive Officer, was one of those taking part in the event. He said: "We want to bring volunteers together – people who are really committed to IPEM growing and changing – and talk about the nature of that change. We want to really bring this thinking into the centre of the organisation and make sure that we have a sustainable lifespan.

"This event is a new kind of experience, and it seems to be opening up people's minds, which was the aim of the day. We want people to think about what the future holds."

The work carried out on the day and the interventions identified will be drawn on when IPEM's *Science Leadership Strategy* is updated and will also contribute towards the future work that IPEM carries out on behalf of its members.

"We need to get a workable agenda," continued Philip. "I don't think we are going to get immediately workable ideas from today, but what we need to do is take the ideas away and start to build them into what we are doing and create practical outcomes in the future."

Always an opportunity

The day was run by SAMI Consulting – an organisation of experts in futures thinking and strategic foresight.

Patricia Lustig, a SAMI Consulting Principal, was one of the team running the event.

"I hope that people will be going away with an understanding that you can't predict the future, but you can make choices that will work well in different futures,"she said.

"There is always opportunity, no matter which future we are in, it is what we do with those futures that is the important thing."

Anna Barnes, IPEM President, thought that the exercise brought people together and produced some interesting ideas. "I'm loving how everyone here is in agreement," she said. "There's not a single dissenting voice in the room in terms of why we are doing this. It's great that we are able to hold this event and see people face-to-face and it has given me some messages that I will take with me through the next two years of being President."

"WE NEED TO TAKE THE IDEAS AWAY AND CREATE PRACTICAL OUTCOMES IN THE FUTURE"

IPEM'S SCIENCE LEADERSHIP STRATEGY

The *Science Leadership Strategy* will reinvigorate IPEM's scientific and technical activity to ensure the medical physics and clinical engineering professions are relevant, engaged and engaging in a changing operating environment.

It complements IPEM's 2025 strategy, particularly the leadership and professional development elements, but also gives focus and guiding purpose to public outreach activities and engagement with other professions.

The strategy defines three grand challenges and three emerging trends, and outlines the key issues that should be incorporated into priorities and action plans. The grand challenges are the major challenges that are increasingly affecting healthcare sciences:

Climate change

- Carbon costing and energy costing essential services and resources
- Improving energy- and carbon efficiency of services without compromising patient outcomes
- Preparing to address the effects of climate change (extreme weather events and changing disease patterns).

Staffing and workforce

- Demonstrating and advocating the value of physics, engineering, and technology in medicine
- Supporting skills development for the workplace of the future
- Exploring fluidity between disciplines and settings to promote retention of talented staff.

Safety and security

- Cybersecurity of cloud and edge systems, Internet of things (IoT) devices and equipment
- Planning and protecting against resource scarcity
- Emergence of new data may expose new concerns with existing practices.

To read IPEM's *Science Leadership Strategy* in full, visit bit.ly/IBMS_SLS

ADVANCED PHYSICS FOR BRACHYTHERAPY

A four-day course

Radiotherapy Physicist **Athina Sdrolia** reflects on learning points from the latest ESTRO course on Advanced Physics for Brachytherapy.

IMAGE: ISTOCK

Advanced Physics for Brachytherapy (BT) is a biennial course run by the European Society for Radiotherapy and Oncology (ESTRO). It was first established in 2014 and is primarily designed for medical physicists interested in expanding their knowledge in the field of BT physics. The drive for its establishment was the gradual and significant increase in BT availability in the 21st century with steadily increasing use of image guidance and inverse planning and rapid evolution of technology and BT-related research. There is now a central role assigned for clinical medical physicists and researchers for development, validation and implementation of such advanced methods and techniques.

Overall, the course aims to:

- Expand on the physics background of recent developments in conventional and contemporary dosimetry methods in modern BT (computational and experimental)
- Provide a detailed review of modern 3D treatment planning techniques and prescription concepts
- Provide an overview of essential quality assurance aspects, *in vivo* dosimetry, treatment verification techniques and associated recent developments
- Review available knowledge on uncertainties and their clinical impact in modern BT
- Offer an overview of upcoming technological advancements in implantation and treatment delivery.

The conference room in the Titania hotel in Athens had an excellent view to the Acropolis and was buzzing with 51 participants from 19 countries (90% from Europe). The vast majority of participants (40) were medical physicists while there was some representation from industry, radiation oncology and other medical specialities. In terms of primary aims, most participants (54%) stated that they were mostly interested in improving their practical skills through this course.

The course, held on 9–12 October 2022, was split into theoretical lectures, delivered by the faculty members, and practical sessions, run

by the two most popular BT Treatment Planning System (TPS) vendors, Elekta and Varian. One of the aspects I loved was the use of real-time audience interaction with polls, Q&A, quizzes and surveys through the Slido platform. Slido facilitated a high level of engagement and offered valuable insight into everyone's experience and ways of clinical practice, often leading to great discussions in the room.

The first day

On the first day, after the warm welcome by the course director Dimos Baltas (University of Freiburg, Germany), we swiftly moved on to a nice introduction to treatment delivery technologies by Mark Rivard (Brown University, US) and to the principles of image-based treatment planning by Dimos Baltas. The main focus of the remainder of the first day was 3D imaging modalities, techniques and registration, tissue segmentation and characterisation as well as QA of 3D imaging. Nicole Nesvacil (Medical University of Vienna, Austria) and Åsa Carlsson Tedgren (Linköping University, Karolinska University, Karolinska Institute, Sweden) demonstrated the advantages and limitations of different imaging modalities and highlighted that we should aim to reduce the need for registration where possible as it introduces a high level of uncertainty to the process. They also stressed the importance of physicists being involved in the optimisation of MRI sequences used in BT – as diagnostic-only sequences are not ideal – and have a say on MRI QA. For MR-only BT, physicists are advised to watch out for distortions, as it is a great source of uncertainty and aim to place the volume of interest in the magnetic isocentre as a way to reduce distortion (AAPM TG 303). T2-weighted MR is advisable for delineation purposes and T1 for applicator reconstruction but these are not necessarily inherently registered as the patient can move and the anatomy can change from the acquisition of one sequence to the next. Finally, contour checking should be done in all views available to reduce uncertainty. The first day closed with two practical sessions on the use of various imaging modalities in BT planning and applicator reconstruction in Oncentra and in Eclipse, with emphasis on common sources of error and how to avoid them.

Above. Group photo of the course delegates having a welcome drink with a view to the Acropolis.

Below. The UK delegates: Jim Daniel, Athina Sdrolia, Victoria Longden, Steve Bolton, Lauren Slater and Claudia Hill.

The second day

The general topic of the second day was dose calculation and commissioning of calculation algorithms. Panos Papagiannis (Course Co-Director, National and Kapodistrian University of Athens, Greece) started us off with a superb lecture on the Monte Carlo (MC) method and its potential to provide reference dose distributions. Even though MC-based TPS is not clinically available for BT yet, it is still the gold standard for single source geometry (TG-43). He made complicated concepts seem a lot simpler, involving the kind of maths which mentally took me back to my undergraduate physics years. Mark Rivard talked analytically about the TG-43 formalism, its purposes and advantages of its simplistic approach while Luc Beaulieu (Université Laval, CHU de Québec, Canada) discussed the important limitations of the TG-43 based dosimetry and how these translate to clinical scenarios (Figure ❸). Essentially, the fundamental assumptions associated with TG-43 (i.e. patient = water, full scatter conditions, no electrons, 3D source geometry not taken into account) lead to uncertainty in dose estimation, which can get quite high in certain situations making it too uncomfortable to continue to ignore. Different anatomical sites have different sensitivities to dose uncertainty with prostate being one of the most problematic ones, especially when calcifications are present, leading to differences in D90% in the order of -10% with a probable domino effect on tumour control probability (TCP). In breast, the experts seem to agree that the overall dose decreases when high levels of contrast are used, skin is over-estimated (4-10%), coverage is slightly overestimated while dose to ribs is generally under-estimated (5-7%). In gynaecological cases without shielded applicators, the deviation from "true dose" is much less than the previous scenarios (within ±5%) however when shielded applicators are employed then there is absolute urgency to move on to model-based dose calculation algorithms (MBDCAs) and the TG-186 formalism for tissue assignment and dose calculation/reporting, keeping in mind that TG-43 is still the standard for prescription dose levels and planning/optimisation. Generally, the clinical benefit of MBDCAs is site-specific but also case-specific.

Åsa Carlsson Tedgren, presented on the advanced collapsed engine (ACE, an adaptation of collapsed cone for BT) developed by Elekta, while Panos Papagiannis presented on Acuros (a grid-based Boltzmann equation solver) developed by Varian. Both presentations were very informative providing in-depth insights. Overall, ACE and Acuros have

many similarities, such as the long heritage, the fact that they are adaptive and employ pre-calculated data, but they also have differences such as in the way they handle energy discretisation. In terms of which one is best, there is no straightforward answer: any of the two can be used to improve accuracy and open new possibilities in the clinic provided that we, as physicists, understand deeply their strengths versus weaknesses. The final lecture for day two was on commissioning of MBDCAs in the clinic by Luc Beaulieu. The standardised commissioning methodology is outlined in TG-186 aiming to maintain inter-institutional consistency. Four standardised benchmarking cases with MC reference data have been developed through the AAPM Work Group using a designed mid-vendor source and for both commercially available high-energy MBDCAs. A publication is underway in 2023 that will provide the detailed workflow, reference data, step-by-step guide, recommendations etc. Just a note that the MC gold reference data sets will not change with time and can be used to validate your own MC implementation. The day closed with a practical session in which we got the chance to explore a benchmarking case and compare MBDCAs vs TG-43 calculated dose distributions.

Day three part 1

The first half of day three focused on optimisation, prescription and evaluation through three lectures and a practical session with the vendors. Nicole Nesvacil started us off with her presentation on the ESTRO prescribing and reporting recommendations for cervix, prostate and breast cases, including worked out examples of EQD2 calculations. She also discussed the valuable dose-effect relationships that have been derived from the EMBRACE and RETROEMBRACE trials. Åsa Carlsson Tedgren then presented on dose plan evaluation, including dose to points (traditional and new), DVH measures, 3D dose distributions, indexes and dwelling time pattern. Dimos Baltas followed with a highly informative presentation on the mathematical concepts of dose optimisation, forward planning, inverse optimisation and planning. One of the useful take-home messages was the importance of smoothing dwell times along catheters as a small number of dominating dwell positions can be problematic in a similar fashion as having too small segments in external beam radiotherapy (EBRT). This is particularly important in elongated structures/sites (i.e. oesophagus) where few dominating dwell positions can cause punctures in critical vessels. It was also highlighted during the practicals that the process of BT plan optimisation can lead to situations where dwell times change in a non-smooth fashion, so the user needs to be vigilant.

Top: Athina Sdrolia.

Above: The Faculty of the 4th Course: (from left to right): Mark Rivard, Dimos Baltas, Åsa Carlsson Tedgren, Nicole Nesvacil, Agnès Delmas, Efi Koutsouveli. Not depicted: Panos Papagiannis and Luc Beaulieu.

Day three part 2

The second half of day three focused on experimental methods for dosimetry. Mark Rivard presented on the very important aspects of source strength measurements, traceability to standards labs around the world, the associated uncertainties and their clinical impact [the 2004 *ESTRO Booklet no. 8* is still a current reference for QA while there are more recent well-established GEC-ESTRO recommendations on calibration and traceability for both low-energy low-dose rate (LDR) and high-energy high-dose rate (HDR) and pulsed-dose rate (PDR) sources]. Panos Papagiannis then discussed various aspects of experimental dosimetry in BT for establishing source reference dose rate distributions, for commissioning/QA testing of TPSs and for dose verification in phantom or *in vivo*. Some key messages from this lecture are that dose rate dependence is a problem in BT dosimetry and the "obsolete" film seems to be the only dose rate independent detector (of the already established ones), which comes with the cost of highly inconclusive data, as manufacturers seem to have been changing properties without notifying users so – beware. Positional accuracy is utterly important as $1/r^2$ rules in BT (0.05mm is about the precision we are after) and so is full knowledge of phantom density variation. MicroDiamond

and microSilicon detectors seem promising alternatives to TLDs and film. The third day closed with Dimos Baltas' presentation on treatment delivery verification as a means of moving away from our heavy reliance on a long list of assumptions. The *in vivo* dosimetry (IVD) concept is blended with the concept of patient-specific QA in BT as our dose delivery system is essentially patient-specific. All that has been explored so far in the literature is mostly experimental (for now); Dimos Baltas talked about electromagnetic tracking for catheter reconstruction and source tracking using an EPID and highlighted the importance of online readout abilities of detectors in such applications. One important message is that we need to be very careful with gamma analysis in BT and tolerances (especially positional) need to be much stricter than what we are used to in EBRT. IVD and verification of source position were suggested as the future of BT treatments and the field of very active and promising research at the moment.

Day four

Day four started with a lecture by Mark Rivard expanding on tracking technologies in IVD. He said one third of reported errors in RT are BT related with human errors more frequent than machine failures. The need (and challenge) is for an IVD system to record a signal in real time (although integrated solutions are also explored) and convert it to dose without perturbing the patient dose itself. It was useful to learn that there is now a dedicated IVD task group under ESTRO that is working on primary guidance documents and concepts for commercial implementations. The presentation on the quantification and clinical impact of uncertainties, by Nicole Nesvacil, which followed was also very informative, going into specific worked-out examples. It was shocking to see that uncertainty for OAR D2cc is expected at 20-30% without any sort of pre-treatment verification. Finally, one of the most eye-opening and useful presentations was the one by Mark Rivard on workflow re-design through failure modes and effects analysis (FMEA) and fault tree analysis (FTA) techniques. I appreciated the in-depth discussion about re-thinking the scoring and multiplication methodology of the occurrence-severity-detectability factors in a non-linear way: perhaps A x B should not be the same as B x A. In that lecture, we were handed a list of 25 checkpoints on an example BT workflow and we were asked to pick and rate four that each participant considers as the most important, sparking a truly interesting discussion and sharing of experience on optimisation of workflows through appropriate QA/QC.

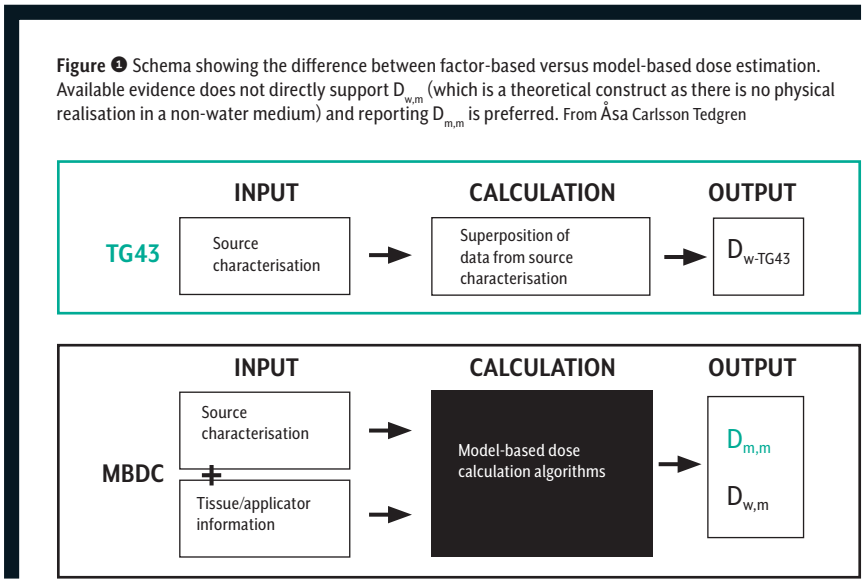


Figure 1 Schema showing the difference between factor-based versus model-based dose estimation. Available evidence does not directly support $D_{w,m}$ (which is a theoretical construct as there is no physical realisation in a non-water medium) and reporting $D_{m,m}$ is preferred. From Åsa Carlsson Tedgren

The takeaways

In terms of radioactive source-based BT, our centre only provides gynaecological treatment and in terms of electronic BT, colorectal treatment, therefore my current practical experience is only pertinent to these sub-fields and I was naturally focusing a bit more on these. But I did find it extremely helpful that I was able to have a go at planning of other sites, such as prostate and breast, in the practical sessions with the vendors. Similarly, I found it very useful to familiarise myself with the commercial system not used in our department. From all I have learnt in the course, if I were to choose one element to implement in my clinic as a priority, that would be FMEA/FTA: this is essential in BT as there are numerous opportunities for errors and I have already agreed with my colleagues that this will become a priority for us in the following year.

I would definitely recommend this course to anyone involved in BT, whether it is through clinical work or research. The level of knowledge and expertise among the teachers was very high and I received informative answers to every question I asked. Every lecturer provided valuable relevant references for further in-depth reading. The practical sessions were very useful, however, I felt that they needed more time allocating and a few more laptops/workstations would have improved the experience further.

I feel it would have been more complete if there was more on electronic BT although one can argue that this can be a whole other category on its own. It was so wonderful to meet and chat with so many colleagues from different places - I've learnt a lot about how physicists work within the BT field in other clinics, in research and in the industry.

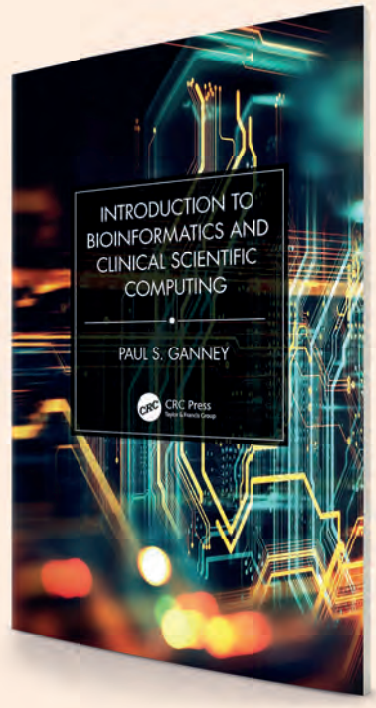
I would like to express my warm thanks to IPEM for kindly covering my travel and accommodation expenses. Many thanks to the Radiotherapy Physics Department at Hull University Teaching Hospitals NHS Trust, for granting me study leave and covering the course fee.

Athina Sdrolia *is a Radiotherapy Physicist at Castle Hill Hospital, Hull University Teaching Hospitals NHS Trust.*

BOOK PITCH

Introduction to Bioinformatics and Clinical Scientific Computing

Dr Paul S Ganney outlines the ideas behind and the content within his new book.



I started working in the NHS as a Computer Scientist in 1985, so I've been around for a long time (my IPEM membership number is 3 – I'm very interested in who 1 and 2 are). During my career I've been active in education and spent time lobbying for Computer Science to be included in the Modernising Scientific Careers programme. Therefore, I was quite pleased when it appeared (under the title "Bioinformatics (Physical Sciences)") and even more pleased when the name changed to "Clinical Scientific Computing". That transition pretty much explains the book title.

The material in the book comes from three of the modules that I teach at MSc level at Liverpool University: Databases and Data Mining, Networking and Hosting and Clinical Software Design. I tend to write my lectures out verbatim (as I'm always afraid of missing something out if I don't) so when I finally got frustrated with the lack of a text book to support the modules (there are lots of text books, but the material is spread through them and I don't really like recommending 10) and having been involved with Azzam Taktak's excellent *Clinical Engineering* textbook, I decided to pitch the idea of this book to Taylor & Francis and they said yes, which made me very happy until I worked out how much work this would involve...

The book is aimed at anyone working in Computer Science, from the specialists to those who "only write a few macros". Across the 19 chapters it covers the material you'd expect from the three modules it's drawn from. In Databases, that's data structures, database design (up to 5th normal form), SQL (and NoSQL), data mining, analysis and presentation and Boolean algebra (for making database queries and program logic more efficient). In Networking, that's architecture (including cloud and virtual storage), encryption, web programming (the closest the book gets to the art of programming), data exchange (including DICOM and HL7) and Backup. In Clinical Software Design, the topics are software engineering (including software lifecycle models), software quality assurance (including various standards), project management, safety cases and critical path analysis.

> **"IT'S THE BOOK I WISH I'D HAD – I HOPE IT WILL BE OF SIMILAR USE TO ALL THOSE IN THE FIELD**

Bioinformaticians/Computer Scientists will be interested in all the material. Physicists and engineers "who write a little code" will (or should) be interested in Boolean algebra, backup, software engineering, software quality assurance, project management and especially safety cases and will find ideas of use in the rest of the material. It's the book I wish I'd had – I hope it will be of similar use to all those in the field. It won't teach you how to code, but if you can code, it'll help you make your code safer, more efficient and maintainable.

***Dr Paul S Ganney** is a Consultant Clinical Scientist at University College London Hospitals*

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