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Volume 31 | Issue 3 | Autumn 2021

IPEM

SCOPE

AIRBORNE TRANSMISSION

How ultraviolet C air sterilisation can be used in clinical environments

IPEM 2025

Key points from the new strategy for the next four years

NUCLEAR MEDICINE

Promising new methods for prostate cancer imaging

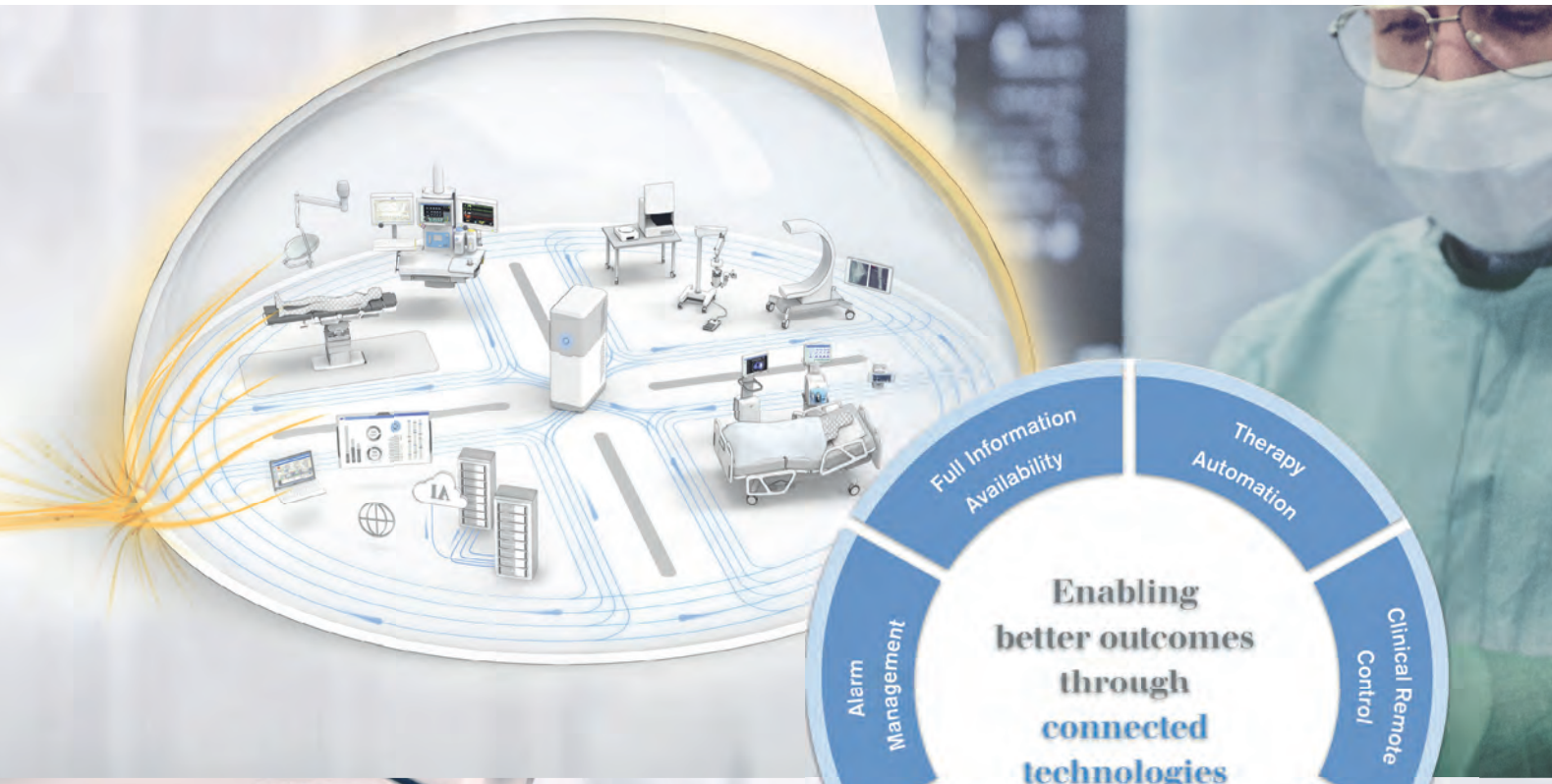
CLINICAL ENVIRONMENT

Control systems in the age of smart technology

COMPUTING

Assessing clinical and scientific computing support

Dräger



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Tackling the issues

Usman Lula outlines the content in the latest issue of *Scope* and encourages members to get involved.

In this issue we ask three experts key questions around cybersecurity and preparedness plans

Welcome all to the latest autumn issue of *Scope* – hope you've had a fantastic summer! Now that most COVID-19 restrictions have been lifted in the UK, there seems to be a flurry of holiday makers making the most out of "Freedom Day". Let's hope self-isolation rules work well for the fully-vaccinated in the coming months!

You may have heard that the Health Service Executive (HSE) of Ireland suffered the most significant ransomware attack in May this year, which caused its critical IT systems to be shutdown at a huge long-term cost. The CONTI ransomware attack caused significant disruptions on health services (around 40 hospitals) for several weeks, also affecting radiotherapy services. Although the "Wizard Spider" group responsible, believed to be operating from St Petersburg, Russia, later provided a decryption key (for free), it continued to threaten to publish or sell data it had stolen unless a $20m ransom was paid. The HSE has now confirmed confidential information for 520 patients, as well as corporate documents, has been published online. In this issue's Big Debate feature, we ask three experts key questions around cybersecurity and preparedness plans. Take a look and see how other organisations are tackling this issue. Thanks to Paul Barrett from the IPEM National Office for providing assistance.

Although it is now established that SARS-CoV-2 spreads predominantly via the airborne transmission route, current policies continue to emphasise the importance of fomite, droplet and direct spread. With this in mind, we have an interesting feature from healthcare scientists and clinical engineers who have been investigating the use of sterilisers and portable air cleaning devices and how the problem can be successfully managed at reduced costs.

We've included part two of Andy Nevill's coaching series in this issue (sorry, this was delayed due to space limits in the summer *Scope* issue) where he presents a case for coaching and shares some personal insights including how it may be used to good effect in the workplace. Enjoy the read!

Usman Lula

Usman Lula
Chair of IPEM *Scope* EAB

CONTENT

Seeking submissions

We aim to ensure *Scope* is filled with interesting, engaging and valuable material, whilst we also continue to improve the quality of the content. We are seeking submissions from the following areas, covering clinical practice developments, leadership and management or topical issues, to ensure *Scope* remains current, relevant and balanced:

- Radiotherapy
- Nuclear medicine
- Diagnostic radiology
- MRI
- Ultrasound and non-ionising
- Radiation protection
- Clinical engineering and biomedical engineering
- Rehabilitation engineering and biomechanics
- Physiological measurements
- Clinical computing.

Articles are welcome from all levels, including trainees, junior, middle, senior and retired staff. If you have a idea, please get in touch at **usman.lula@uhb.nhs.uk**.

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Institute of Physics and Engineering in Medicine

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CO

CLINICAL

14/ THE BIG DEBATE: CYBERSECURITY AND PREPAREDNESS PLANS

With increased reliance in the connected modern world on just-in-time supply chains and cloud services, our data has never been so vulnerable. Three experts discuss the wide-ranging impacts of cybercrime on healthcare and the future direction of cybersecurity in preventing an attack.

> The only way to mitigate the threats is to use military-grade encryption techniques to safeguard data.
>
> – *Professor Muttukrishnan Rajarajan* page 14

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Cover image by
MARIO WAGNER

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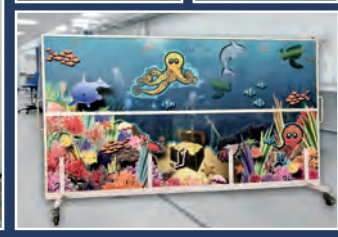

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UPFRONT

COVID-19

Could lateral flow tests be as effective as PCR?

A new international study has found that lateral flow tests detect COVID-19 with similar accuracy to laboratory-based PCR tests – providing they are used at the onset of infection and soon after symptoms start.

The finding could be pivotal to national strategies looking to tackle the next phase of the pandemic, especially as timely and rapid testing becomes even more important with the lifting of restrictions.

As part of the study, over 2500 people with mild to moderate flu-like symptoms were assessed by GPs in the district of Liezen (population 79,652), Austria, between October 22 and November 30, 2020 and tested for viral antigen using lateral flow tests.

Those who were suspected to have COVID-19 were also tested using a PCR test.

The lateral flow tests detected more than 95% of the cases found by PCR, and correctly identified 89% of cases as negative. The study is the first to compare lateral flow and PCR testing on the same group of people on a large scale.

It also included the variables of a real-world setting: five different brands of test kit, three laboratories, and professional swabbing offered at 20 different GP practices.

IMAGE: SHUTTERSTOCK

The lateral flow tests detected more than 95% of the cases found by PCR, and correctly identified 89% of the negative

Study author Dr Werner Leber from Queen Mary University of London said: "Previous studies have suggested lateral flow tests may be less sensitive than PCR in detecting COVID-19, particularly among asymptomatic individuals and during the early or late stage of an infection when the viral load is lowest.

"But we have found that in patients who are newly symptomatic, the two testing methods have similar levels of accuracy.

"Countries are considering using lateral flow tests to manage future waves of the pandemic. Our findings support this move, but ensuring tests are properly administered should be integral to any strategy."

Behind the study were researchers from Queen Mary University of London, University of Oxford, Institute for Advanced Studies, Vienna, and the Medical University of Graz.

bit.ly/3faAy8D

FAST FACTS

1ST STUDY
This is the first major study to compare lateral flow and PCR testing on the same group of people.

2500
Over 2500 people with mild to moderate flu-like symptoms were assessed.

95% EFFECTIVE
The lateral flow tests detected more than 95% of the cases found by PCR.

MEDICAL IMAGING

New microscope technology

Researchers from South Korea have developed a new optical microscope technology, capable of deeper imaging beyond the biological tissues.

At present, the limited penetration depth of the optical microscope makes it difficult to observe biological tissues of more than 100 µm thickness. Light scattering – caused by components such as lipids – makes the subject out of focus.

In this study, the research team at Ulsan National Institute of Science and Technology showed that for wavefront shaping in thin anisotropic scattering media, such as biological tissues, they can optimise the wavefront shaping quality by limiting the numerical aperture (NA) of the incident wavefront.

The team also demonstrated that the wavefront shaped focus peak to background ratio can be increased by a factor of 2.1, while the energy delivery throughput can be increased by a factor of 8.9 through 710 µm thick brain tissue by just limiting the incident NA.

It is anticipated that the new approach can open new avenues in a variety of biomedical applications.

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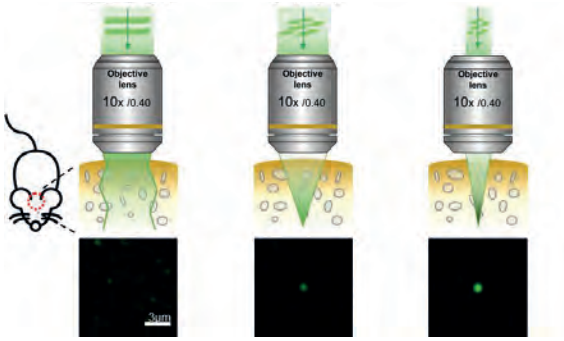

COMPUTER SCIENCE

ARTIFICIAL INTELLIGENCE MODEL TAKES SHORTCUTS THAT INTRODUCE BIAS

A new study led by researchers from the University of Chicago shows that deep learning models trained on large sets of cancer genetic and tissue histology data can easily identify the institution that submitted the images.

The models, which recognise certain cancer signatures, end up using the submitting site as a shortcut to predicting outcomes for the patient, grouping them with patients from the same location instead of relying on the biology of individual patients.

This may lead to bias and missed opportunities for treatment in patients from racial or ethnic minority groups who may struggle with access to care.

Alexander Pearson, co-senior author, said: "We identified a glaring hole in the current methodology for deep learning model development, which makes certain regions and patient populations more susceptible to be included in inaccurate algorithmic predictions."

go.nature.com/2V99e3n

NEWS IN BRIEF

Detecting bad breath

Researchers have constructed a portable, thumb-sized device that diagnoses bad breath by quickly "sniffing" exhalations for the gas hydrogen sulfide. The device correctly identified bad breath 86% of the time when real breaths from people were exhaled directly onto it. The researchers say that their sensor could be incorporated into very small devices for quick and easy self-diagnosis of bad breath.

bit.ly/3zq9vh9

Snakes and sensors

A collaborative team from the Terasaki Institute for Biomedical Innovation were inspired by snakes in the creation of wearable sensors with wide-ranging strain sensitivity. They based the design of their sensor on the overlapping scales that snakes have, which allow them to stretch to multiple times their normal body size when ingesting prey. "The key point in the development of this sensor is its novel structural design," said lead researcher Shiming Zhang. "It makes it possible for our device to measure a wide range of strain levels with a high degree of sensitivity."

bit.ly/2Wg6ykX

Radiotracer

A new radiotracer that detects iron in cancer cells has proven effective, opening the door for the advancement of iron-targeted therapies for cancer patients. The radiotracer, 18F-TRX, can be used to measure iron concentration in tumours, which can help predict whether a not the cancer will respond to treatment.

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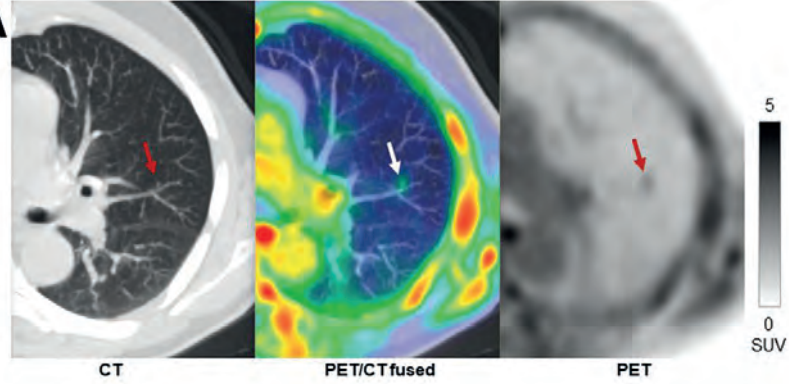


PET IMAGING

Total-body imaging exceeds industry standards

A performance evaluation of the uEXPLORER total-body PET/CT scanner showed that it exhibits ultra-high sensitivity that supports excellent spatial resolution and image quality.

Given the long axial field of view of the uEXPLORER, study authors have proposed new, extended measurements for phantoms to characterise total-body PET imaging more appropriately.

uEXPLORER is the world's first commercially available total-body PET scanner.

In this study, researchers used phantoms to assess the uEXPLORER's sensitivity, count-rate performance, time-of-flight resolution, spatial resolution, image quality and accuracy of corrections based on NEMA NU 2-2018 standards. Human studies were also conducted.

Eric Berg, PhD, project scientist in biomedical engineering at the University of California, said: "Our results with the uEXPLORER PET/CT system show a major gain in sensitivity compared to conventional PET systems, approximately 15- to 68-fold higher than others."

bit.ly/2TwNEVU

UP CLOSE

COTININE

WHAT IS COTININE?

Cotinine is an alkaloid that is found in tobacco. It is also the predominant metabolite of nicotine.

WHAT IS IT USED FOR?

Cotinine can be used to evaluate tobacco use or exposure to tobacco smoke because it has a half-life in the body of between seven and 40 hours, while nicotine has a half-life of one to four hours.

ARE THERE SOME NEW DEVELOPMENTS WITH COTININE?

A pilot study, presented at the 2021 European Association of Urology Congress, found that patients with high levels of cotinine were four times more likely to have their cancer return, compared to those with lower levels of the chemical.

WHAT ARE THE IMPLICATIONS?

A urine test for cotinine could reduce the number of invasive investigations that cancer patients undergo following diagnosis and treatment.

WHAT DID THE STUDY INVOLVE?

The team checked the cotinine levels of 135 patients who were attending hospital for follow up cystoscopies over an 18-month period. The only patients included in the study were those with low-risk bladder cancer, who had not received chemotherapy or radiotherapy and had no other condition, such as urinary infections.

WHAT'S NEXT?

Although the sample size was small, the researchers say the results show cotinine could be a potential biomarker for recurrence of bladder cancer and is worth further investigation.

GENOMICS

FINAL RESULTS FOR CANCER BLOOD TEST

A blood test that can detect more than 50 types of cancer has been shown as accurate enough to be rolled out as a multi-cancer screening test among people at higher risk of the disease.

Researchers report that the test accurately detected cancer, often before any symptoms arose. It also predicted where in the body the cancer is located.

GRAIL, the company developing and funding the research, has now made the multi-cancer early detection test available in the US.

The test involves analysing blood samples for cell-free DNA, which tumours (and other cells) shed into the blood. Genomic sequencing is used to detect chemical changes to the DNA called "methylation" that control gene expression, and a classifier developed with machine learning uses these results to detect abnormal methylation patterns that suggest cancer is present.

bit.ly/3758O0l

IMAGES: SHUTTERSTOCK / UNST / Y. ABDELHAFEZ AND B.A. SPENCER

DIAGNOSTICS

THE COVID-19 DETECTING FACEMASK

A novel facemask developed by engineers can diagnose the wearer with COVID-19 within about 90 minutes.

The masks are embedded with tiny, disposable sensors that can be fitted into other facemasks and could also be adapted to detect other viruses.

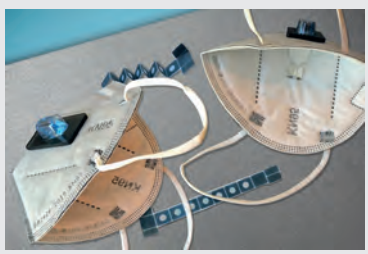
The sensors are based on freeze-dried cellular machinery that the research team has previously developed for use in paper diagnostics for viruses such as Ebola and Zika.

In a new study, the researchers from Massachusetts Institute of Technology and Harvard University showed that the sensors could also be incorporated into clothing such as lab coats. This potentially offers a new way to monitor health care workers' exposure to a variety of pathogens or other threats.

Senior study author James Collins said: "We've demonstrated that we can freeze-dry a broad range of synthetic biology sensors to detect viral or bacterial nucleic acids, as well as toxic chemicals, including nerve toxins."

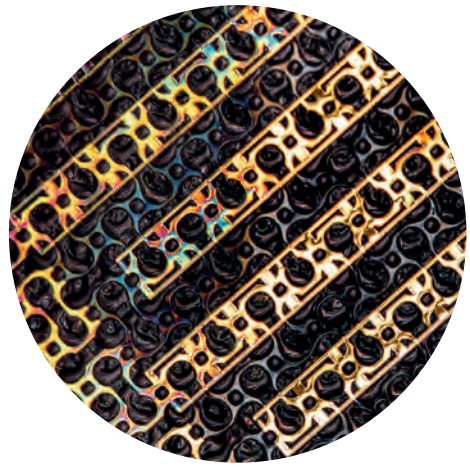
The facemask sensors are designed to be activated by the wearer when they're ready to perform the test. Results are only displayed on the inside of the mask.

go.nature.com/3y2n0mq



MATERIAL SCIENCES

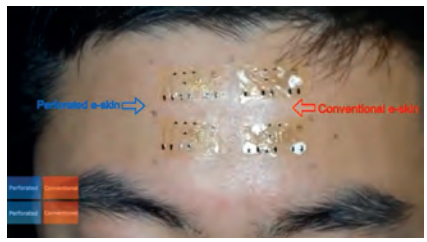
Sweat-proof smart skin



Engineers have developed a sweat-proof "electronic skin" – a conformable, sensor-embedded sticky patch that monitors a person's health without malfunctioning or peeling away, even when a wearer is perspiring.

The patch is patterned with artificial sweat ducts, similar to pores in human skin, that the researchers etched through the material's ultra-thin layers.

The pores perforate the patch in a kirigami-like pattern, similar to that of the Japanese paper-cutting art. The design ensures that sweat can escape through the patch, preventing skin irritation and damage to embedded sensors.



The kirigami design also helps the patch conform to human skin as it stretches and bends. This flexibility, paired with the material's ability to withstand sweat, enables it to monitor a person's health over long periods of time, which has not been possible with previous 'e-skin' designs.

The study's authors says the results are a step towards long-lasting smart skins that may track daily vitals or the progression of skin cancer and other conditions.

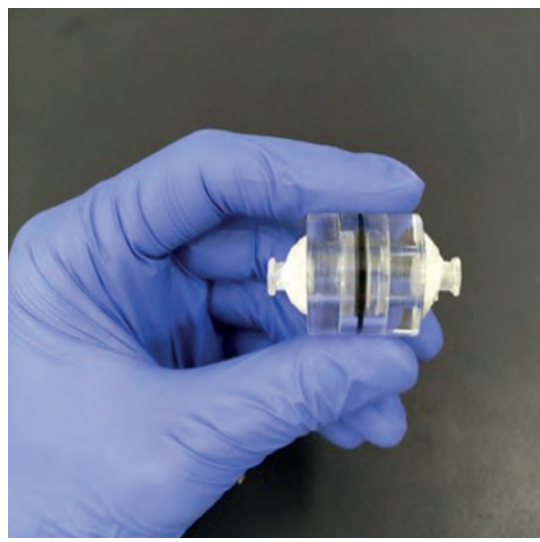
Jeehwan Kim, study co-author, said: "With this conformable, breathable skin patch, there won't be any sweat accumulation, wrong information, or detachment from the skin. We can provide wearable sensors that can do constant long-term monitoring."

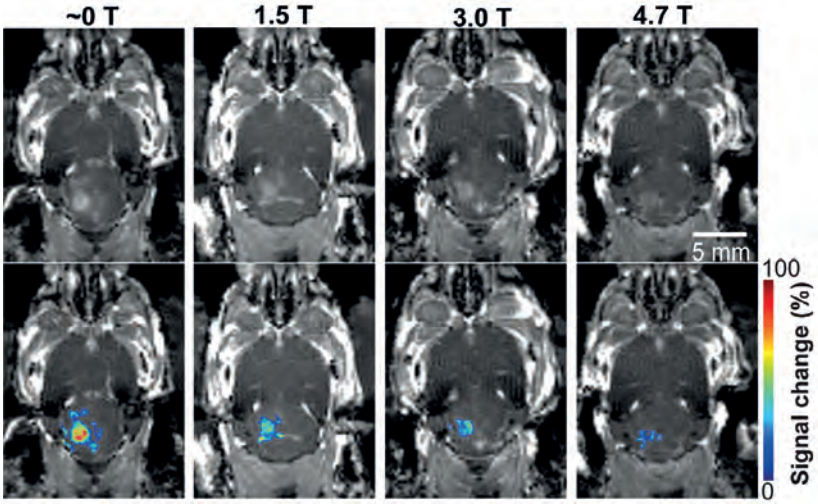
bit.ly/3zw3xLz

BIOMEDICAL ENGINEERING

MICROFILTER FOR DETECTING CANCER CELLS

A microfilter device that can easily separate and capture trace amounts of cancer cells in blood has been developed by a research group at Kumamoto University in Japan. It is hoped that the palm-sized device can contribute to the development of new cancer diagnostic technologies based on cancer cells in the blood, such as early detection by





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RADIOLOGY

OPENING THE BLOOD-BRAIN BARRIER

MRI-guided focused ultrasound combined with microbubbles can open the blood-brain barrier (BBB) and allow therapeutic drugs to reach the diseased brain location under the guidance of MRI.

It is a promising technique that has been shown safe in patients with various brain diseases, such as Alzheimer's diseases, Parkinson's disease and ALS.

While MRI has been used for treatment guidance and assessment in research and studies, researchers did not previously know the impact of the static magnetic field generated by the MRI scanner on the BBB opening size and drug delivery efficiency.

Hong Chen and her lab at Washington University in the US have found for the first time that the magnetic field of the MRI scanner decreased the BBB opening volume by 3.3-fold to 11.7-fold, depending on the strength of the magnetic field, in a mouse model.

A total of 30 mice, in four groups, received the microbubbles, three groups received focused-ultrasound sonication at different strengths of the magnetic field, while one group never entered the magnetic field.

They found that the activity of the microbubble cavitation, or the expansion, contraction and collapse of the microbubbles, decreased compared with those that had received the dose outside of the magnetic field. None of the mice showed any tissue damage from the procedure.

bit.ly/3kTeJhk

blood test, postoperative management, and recurrence monitoring.

Although devices for detecting cancer cells in the blood have been developed in the past, they require expensive equipment and reagents.

This unique device can easily and inexpensively separate and capture circulating tumour cells without any large equipment. It is dynamically and three-dimensionally deformed by the fluid force when blood is pumped through it. It also uses nucleic acid aptamers, which bind specifically and firmly to target molecules. This enables size-selective and affinity-selective separation and capture of tiny cancer cells.

go.nature.com/36VV8ou

BIOTECHNOLOGY

Mass COVID-19 testing

A new COVID-19 test developed can analyse a large number of swabs simultaneously using sequencing technology and has a similarly high sensitivity as the common qPCR test.

The innovative method offers great potential, especially for systematic testing in childcare settings, schools or companies.

The innovative test, LAMP-Seq, which has been developed at the University Hospital Bonn in Germany, offers the possibility to test many people regularly for the SARS-CoV-2 virus.

"Our corona test can detect about 100 times lower amounts of virus than current rapid antigen tests and is almost as sensitive and specific as the common qPCR test," said Professor Dr Jonathan Schmid-Burgk.

"Added to this is the high scalability of the test. By using sequencing machines, thousands of samples can be analysed simultaneously."

The scientists are currently working on CE certification in order to make the LAMP-Seq test available internationally in the near future.

Until this approval is obtained, the technically and scientifically fully validated LAMP-Seq method will continue to be used for pilot testing.

go.nature.com/36VV8ou

EXTERNAL RELATIONS MANAGER

Reform and regulation

Sean Edmunds, the Institute's External Relations Manager, outlines the latest policy news and Institute updates.

Regulating healthcare professionals and protecting the public was the subject of a government consultation that IPEM responded to earlier this year.

The Department of Health and Social Care launched the consultation on proposals to reform the regulation of healthcare professionals, covering four areas: governance and operating frame, education and training, registration, and fitness to practice.

This built on the department's original consultation on the issue four years ago, 'Promoting professionalism, reforming regulation', which IPEM also responded to at the time.

IPEM's Professional and Standards Council produced a comprehensive response to the latest, 70-question long consultation. In the response, IPEM highlighted its desire to see the introduction of statutory registration for clinical technologists, who are currently part of a voluntary register but have been lobbying to be regulated for around 20 years.

The response also included some of the following points:

- Regulators should be under a duty to cooperate with each other for patient safety reasons, they should be transparent and should assess the impact of any proposed changes to their rules on patients

IPEM has highlighted its desire to see statutory registration

THE COVID-19 BACKLOG

A special cancer summit was held earlier this year to make recommendations to the government on how to tackle the COVID-19-induced cancer backlog.

The report, *Catch Up With Cancer – The Way Ahead*, was drafted following an inquiry launched by the All-Party Parliamentary Groups for Radiotherapy (APPGRT), Health and Cancer, who came together to launch the consultation 'Solutions to the Covid-induced cancer backlog'.

IPEM's Radiotherapy Professional Standards Panel (RTPSP) produced a detailed response to this. Dr Vivian Cosgrove, Chair of the RTPSP, was then invited to present the evidence in person at a roundtable event held before the summit to help inform the report. He was one of only 12 people out of the more than 40 royal colleges, clinicians, charities, organisations, patients and individuals who submitted responses to be asked to do so.

Dr Cosgrove discussed IPEM's submission in more detail with parliamentarians, including Tim Farron MP, Chair of the APPGRT and Vice-chair Grahame Morris MP.

He then attended the cancer summit to launch the report, which was attended by a range of cancer stakeholders, medical colleges, clinicians and charities on what more can be done in terms of policy and practical solutions. It is hoped the report will secure parliamentary support for the seven recommendations that have been made. Dr Cosgrove was also a signatory to a letter sent from the APPGRT to Prime Minister Boris Johnson, drawing his attention to the issue.

- All regulators should have the power to approve, refuse, re-approve and withdraw approval of education and training providers, qualifications, courses or programmes of training that lead to registration or annotation of the register
- Regulators should retain all existing approval and standard setting powers providing it is completed in consultation with the profession. Regulators should set standards, the "providers of training" should set the exams/assessment to the standard set by the regulator
- Regulators should hold a single register that can be divided into parts for each profession they regulate
- IPEM agreed with all the fitness to practice proposals and appeals processes being put forward as they are consistent with what the Health and Care Professions Council already does.

"CLINICAL TECHNOLOGISTS, HAVE BEEN LOBBYING TO BE REGULATED FOR AROUND 20 YEARS

Two linked consultations were launched by the Welsh Health Specialised Services Committee (WHSSC) on PET-CT provision in the country. The Nuclear Medicine Special Interest Group (SIG) looked at the proposals and felt there was no need to respond as the WHSSC had included IPEM's suggestions made in 2020 when they had last consulted about this.

As SIG Chair Dr Fergus McKiddie commented, it was "nice to note they had taken our comments on board".

A survey was also held by the European Federation of Organisations for Medical Physics, which looked to explore the interprofessional relationships of medical physicists in Europe. Matthew Dunn, IPEM's Vice President for Medical Physics, with input from Dr Jemimah Eve, IPEM's Workforce Intelligence Unit Manager, responded to this very detailed and wide-ranging questionnaire.

Finally, NHS England and NHS Improvement launched a consultation on the "Diagnostic imaging networks workforce toolkit". A number of IPEM SIGs provided their thoughts and comments on this, which Mr Dunn collated and submitted in response to this consultation.

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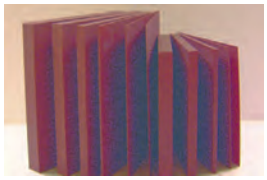

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IMAGE: IKON - STAURT KINLOUGH

THE BIG DEBATE

Cybersecurity and preparedness plans

We hear from three experts, who discuss the most pressing issues around cybercrime in healthcare, academia and industry.

Q *What can we learn from the impact of cyberattacks that have already taken place?*

PROFESSOR MUTTUKRISHNAN RAJARAJAN

There are multiple facets to this question. First and foremost, any sensitive data has to be protected using state-of-the-art security algorithms. It is also important to continuously upgrade the hardware and software systems to protect against any cyberattacks. Always have all the necessary information duplicated and stored securely somewhere where it can be accessed quickly in the event of a ransomware attack. Monitoring IT and digital systems continuously for any anomaly can help to prevent any cyberattacks. In addition, having regular risk assessments can help to identify systems that are vulnerable to any cyberattacks.

PHIL BOOTH

The impact of cyberattacks is often narrowly measured in terms of financial cost, loss of data or downtime, and only sometimes in terms of reputational damage, especially where lack of security has been egregious. However, in contexts such as healthcare – where public and individual trust are paramount to the functioning of the service – loss of confidence itself is considered to be a systemic harm.

PROFESSOR ANDREW REILLY

It's not a case of 'if' but 'when' an organisation will be impacted by a cyberattack. Even with comprehensive practical security measures and training strategies, it's impossible to fully account for human factors, and bad luck still happens. With increased reliance in the connected modern world on just-in-time supply chains, cloud services and immediate data transfers, an attack on any link in the chain can have wide-ranging impact.

It is crucial that all organisations develop and maintain a cybersecurity strategy. This involves bringing the right team of experts together to balance risks, determining the optimum arrangement of protective measures to ensure clinical services can continue to be delivered as planned. IPEM members have an important role to play in this team.

Q *What are the ways in which your workplace has strengthened its cybersecurity in recent times?*

MUTTUKRISHNAN

In recent times my organisation has implemented two-factor authentication to protect any unauthorised access to our systems. All staff have also been asked to take a cybersecurity awareness training online and complete a module as part of the personal development programme. In addition, all data that is stored in the laptops are fully encrypted to protect against any unauthorised access. We also have much stricter information security policy in place and all external emails are flagged up with a warning at the top of the message to alert the recipient. There is also strict guidance in terms of how the student data can be stored and shared.

PHIL

This is perhaps not as relevant to us directly; when we spot a cybersecurity issue with an NHS system or programme, medConfidential would generally escalate to the relevant body and/or National Cyber Security Centre. But in health – certainly across the NHS, since it was formally mandated in 2018 – organisations and suppliers should have at the very least have implemented the National Data Guardian's 10 data security standards (see **bit.ly/3yuBeNw**) and be proactively reviewing their processes. Upgrading thousands of NHS computers from Windows XP to Windows 10 by early 2020, years after the WannaCry incident, was also long overdue.

ANDREW

There is an increased awareness of cybersecurity and other IT

"IT'S NOT A CASE OF 'IF' BUT 'WHEN' AN ORGANISATION WILL BE IMPACTED BY A CYBERATTACK

MEET THE EXPERTS

PROFESSOR MUTTUKRISHNAN RAJARAJAN
Professor of Security Engineering and Director, Institute for Cyber Security, School of Mathematics
University of London

PHIL BOOTH
Coordinator
medConfidential

PROFESSOR ANDREW REILLY
Scientific Director, Department of Clinical Physics and Bioengineering
NHS Greater Glasgow and Clyde

IMAGES: ISTOCK / ALAMY

standards, and moves towards adopting these. While this is positive, both the magnitude of the initial task and the overhead in maintaining compliance can be considerable. Already being familiar with medical equipment and clinical risk management, quality systems and external peer review, medical physics and clinical engineering (MPCE) departments are in prime position to contribute to this and in some places play a leading role. Raising awareness of cybersecurity risks through targeted end-user training is also a common theme, complemented by more human-friendly and effective password management policies.

Q *What is your emergency preparedness plan should there be a successful cyberattack in your work area(s)?*

MUTTUKRISHNAN

There are risk management processes in place to mitigate any cyberattack. We also have Cyber Essentials certification, which will help us to identify any ongoing vulnerabilities in the system. We have external companies monitoring our systems regularly to understand the threat vectors so that any attacks can be stopped and mitigated quickly. We also have duplicate databases to protect our organisation in the event of a cyberattack so that the business can continue to operate.

PHIL

Again, as a general approach, and as with WannaCry, to understand the attack as best we can and then to attempt to inform and maintain calm in the media.

More widely across the sector, since 2018 every NHS body has been required to have extensive contingency plans so they can respond to threats to data security. While such planning has been manifested in terms of business systems resilience – i.e. keeping critical health services running in a crisis – the NHS 'emergency preparedness, resilience and response' approach would clearly benefit from better planning around cybersecurity. Or else why did the Government put Government Communication Headquarters (GCHQ) in charge of keeping NHS systems safe when the pandemic hit?

IPEM SCIENCE STRATEGY

FOCUS ON DIGITAL HEALTH AND CYBERSECURITY

The NHS Long Term Plan and NHSX digital transformation strategy demonstrate a strong commitment to the adoption of new digital technologies across the NHS. This will enable an increase in provision of at-home services – including remote monitoring and patient-led healthcare – brought to the fore by the pandemic and seen as central to the future direction of the NHS. However, cyberattacks such as the 2017 WannaCry ransomware attack – as well as more prosaic failures such as the 2016 crash caused by mass emailing – highlight vulnerabilities and the huge impact systems failures can have.

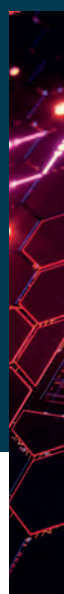
Increasing digitisation offers extraordinary potential but also amplifies the risk from cyberattack, in exposing sensitive data and potentially the operation and reliability of medical devices and systems in both clinical and community settings. Safeguarding against such threats will require investment in infrastructure, training and continuous development, as well as vigilance at institutional and individual levels.

As part of its forthcoming Science Strategy, IPEM will seek to curate professional knowledge in digital health and cybersecurity, and will develop tools to help equip you with up-to-date and practical guidance.

IPEM needs your input!

IPEM is looking for members interested in this field to participate in focus groups and/or surveys to assess the digital health landscape and share thoughts and opinions on digital innovations – including machine learning, AI, remote monitoring, data and cybersecurity. Your valuable time and experience will help IPEM form the best response to support members now and in years to come.

To get involved, or for an informal chat, please contact IPEM's Professional Knowledge and Innovation Manager Catriona Inverarity at **catriona@ipem.ac.uk**



ANDREW
Like most organisations, we have a suite of business continuity and disaster recovery plans that can be activated in the event of a major incident. Experience gained during recent widescale medical device recalls and preparing for EU exit has emphasised the importance of testing and refining plans over time. Responsibilities need to be clearly laid out, risks identified and actively managed, and the whole exercise must be backed by clear leadership and communications strategies. Recognising that the full impact of a cyberattack cannot be predicted in advance, our organisation has a mechanism for establishing a rapid response team that will draw on relevant expertise from across the organisation to actively manage any emerging incident.

Q *How does a pandemic change your approach to cybersecurity?*

MUTTUKRISHNAN
We implemented two-factor authentication. In addition, all video-calling platforms are regularly updated with the latest software versions and patches so any known security holes are fixed on a timely manner. Implementing a strict Zoom and Microsoft Teams user access policy blocks any external unauthorised users accessing the systems. There is also continuous monitoring in place to identify any zero-day attacks. The antivirus software is automatically updated on a regular basis and all the devices are protected with endpoint security. Also, all laptops encrypt information or store data by default.

PHIL
Clearly we can't comment as a hospital, but during the pandemic GCHQ was granted additional powers by Matt Hancock in April 2020, allowing it to request from the NHS anything "relating to the security of any network and information system". For more information, visit **bit.ly/3CvO7cM**.

ANDREW
My experience has been that when working in extraordinary circumstances the team's awareness is already heightened to safety concerns. Therefore, with clear and active leadership, it is possible to safely work through the emerging problem as a team. However, two key foundational elements are required for this to be successful: that the team members care for each other at a human level in order to avoid exhaustion, and that sound standard operating procedures are available to fall back on that include how decisions are made, documented and reviewed. These enable team members to fully trust both the system and each other. Working towards service accreditation helps to cement this relationship.

Q *What do you see as the future direction of cybersecurity and resilience in healthcare over next five to 10 years?*

MUTTUKRISHNAN
The health sector will continue to see major cyberattacks due to the penetration of wearables, remote surgeries and online consultations. The only way to mitigate the threats from these types of attacks is to use military-grade encryption techniques to safeguard the sensitive data. In addition, privacy-preserving data analytics techniques such as differential privacy and federated learning can be used to perform clinical analysis on encrypted data. There are great opportunities for healthcare innovations through wearables, robotics and artificial intelligence in the next five to 10 years. This can help to reduce the burden on healthcare professionals.

PHIL
Hopefully, adequate investment in up-to-date systems and software; greater standardisation permitting better system-wide protections and interoperability; more openness and transparency of audit trails; and the use of trusted research environments rather than the dissemination of population-scale, patient-level linked datasets.

ANDREW
MPCE departments will have an increasing role in developing cybersecurity strategies and implementing emerging IT infrastructure technologies, including the move to cloud solutions. I envisage a particular role for clinical scientists and technologists in clinical bioinformatics as being the glue between IT professionals and more traditional healthcare science specialisms. It would be ideal for IPEM members to step up to fulfil the role of clinical safety officer for their department or organisation, ensuring the balance between security and utility is in the best interests of patients and service users.

AIRBORNE TRANS-MISSION

Analysis of how ultraviolet C air sterilisation can be used in clinical environments to reduce airborne transmission of SARS-CoV-2.

During the second wave of the SARS-CoV-2 pandemic, the number of patients admitted into hospital rose steadily across the UK, from a weekly average of 122 on 1 September 2020 to 2037 on 17 December, eventually reaching a peak of 4232 cases per week on 9 January 2021. During this time, the NHS continued to deliver with other non-COVID admissions and elective surgery.

The increase in hospital admissions led intensive therapy unit (ITU) teams to consider expanding to ward areas to manage SARS-CoV-2 critically ill patients.

They requested an urgent review of the feasibility, efficacy and safety of ultraviolet C (UVC) air sterilisation devices to reduce the length of the fallow period between patient procedures required for the room ventilation system to clear air potentially contaminated by viral-loaded, aerosol-generated particles.

Health and care workers are at three to four times greater risk of developing and dying from COVID-19 than the public. However, measures to reduce airborne spread in high-risk health and care settings, which are mission-critical to the pandemic response, have thus far been inadequate and overlooked.

Current policies continue to emphasise the importance of fomite, droplet and direct spread but do not properly address airborne transmission. It is now established that SARS-CoV-2 spreads predominantly via the airborne route and is readily transmitted in health care settings beyond formally classified aerosol generating procedures (AGPs).

Importantly, attempts to engineer more rapid room air exchanges through modifications of existing buildings' heating, ventilation and air-conditioning (HVAC) require significant engineering works, which are extremely expensive and disruptive. A recent proposal to make structural alterations to a ward ventilation system was rejected by the senior clinical and management teams, mainly because the hospital could not cope with losing 24 beds for up to three months, given its backlog and ongoing clinical admissions. We anticipate there would be similar issues across the UK.

Computational fluid dynamics (CFD) offers insights into ventilation efficiency and contamination spread not previously available in the original design of the existing treatment spaces.

An alternative approach to such major HVAC

FAST FACTS

A SHORT HISTORY OF ULTRAVIOLET GERMICIDAL IRRADIATION (UVGI) FOR AIR DISINFECTION

1877
The discovery was made that sunlight can prevent microbial growth

1933
The concept of airborne infection via "droplet nuclei"

1937
UVGI is used to prevent epidemic spread of measles in suburban Philadelphia schools

1940s-1950s
Studies unable to reproduce the success of 1937 led to a decline in interest around UVGI

1985-1992
There is an unexpected rise in TB in the US after decades of decline, leading to a renewed interest in UVGI for air disinfection

1990-PRESENT
In-depth efforts are made to quantitatively examine UVGI efficacy and safety and to create guidance for the use of UVGI

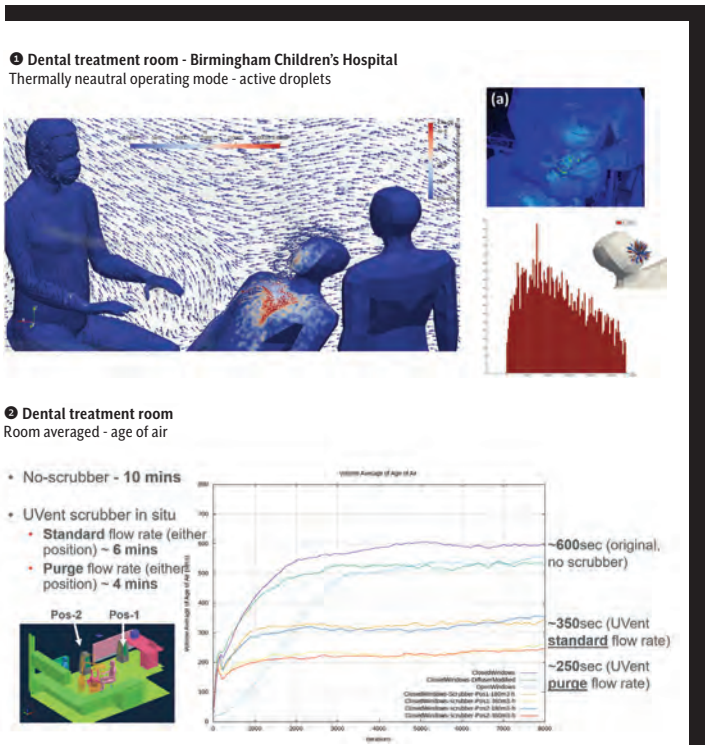
upgrades is to install local air cleaning (sterilisation/sanitisation) devices, which can draw-in contaminated room air and return "cleaned" air by using techniques to reduce airborne particles. The work presented here focused on devices which incorporate UV lamps that have the ability to deactivate the SARS-CoV-2 virus.

Although the reactive response here by Clinical Engineering at Hywel Dda was directed towards AGPs in ICU and endoscopy suites, here we illustrate our CFD approach with parallel work led by Peter Bill in Dental Theatres in Birmingham Women's and Children's NHS Foundation Trust.

Objective: to review existing data on UVC air sterilisation

Main questions

1. What effect does UVC radiation (250 nm) have on bacteria and viruses, particularly SARS-CoV-2?
2. How could we predict UVC efficacy in a real world setting through the use of computational modelling and/or environmental air sampling?
3. Background.



UVC radiation is a well-established disinfectant for air, water and non-porous surfaces. The use of UVC air cleaning devices are proposed as an adjunct to HVACs in mitigating airborne transmission risks in poorly ventilated spaces. In the US, the most common HVAC practice is to mix 20% external "new" air with 80% recirculated "old" air. Recirculated air is sanitised using high-efficiency particulate air (HEPA) filtering and UVC light radiation. While the science and engineering of 250 nm UVC sanitisation are understood, a limitation of previous SARS-CoV-2 bio-validation studies only considered in vitro efficacy. There has been no evaluation of this technology in a real-world clinical setting, where AGPs are the major hazard.

Through the Healthcare Science COVID-19 Clinical Engineering National Network Meeting, the expert consensus [personal communications, Professor Tony Fisher of Liverpool University, Professor Cath Noakes of University of Leeds and SAGE, and Dr Alan Beswick, Public Health England and SAGE] is that UVC air sterilisation devices are effective in providing useful numbers of additional equivalent room air changes above and beyond the underlying hospital HVAC system.

However, air sanitisation is not just dependent on the air changes per hour (ACHs) but also the efficiency of total room airflow handling. The Leeds group suggest

IMAGES: SHUTTERSTOCK / ISTOCK

ADVANTAGES AND DISADVANTAGES

OF UVC AIR STERILISATION DEVICES WITHIN A WARD SETTING

ADVANTAGES

- Quiet to run, two settings (normal and boost).
- Staff can still work in the bays; no impact upon nursing staff working around them.
- Ergonomics are good.
- Patients can sleep comfortably with them on.
- Patients walking can see them in the bay; no trip factor for dementia patients.
- Nursing staff feel they have had an improvement in the air quality on the ward, and so do others on the ward – "It does feel cleaner" and "We wish we had had these at the start of the pandemic".

DISADVANTAGES

- Unable to advise on engineering verification and bio-validation.
- Compliance unclear with respect to HSE and MHRA regulation.

that portable plug-and-play UVC air sterilisation devices might be modelled at ≤75% of the performance claimed by the manufacturers.

The most successful experience with UVC in Liverpool so far is with the mobile floor-mounted Mansfield Pollard UVent. On the National Mobile Processing Labs Programme, Professor Fisher advised they were using a combination of UVent units and PurisAir machines (which use electrostatic filters rather than UVC) .

Professor Paul White in Cambridge has trialled a number of UVC air sterilisation devices in the ITU, working with clinicians and hospital infection control teams. They intuitively placed the position of these sterilisers to optimise effective ACHs. The team used NIOSH air samplers to collect SARS-CoV-2, which was detected using highly sensitive PCR techniques.

Sampling was optimised in eight-hour blocks as the airflow across the filter destroys the viral DNA over longer time periods. They aimed to run a baseline for a few weeks and then repeat with UVC air sterilisation devices on to see if they could minimise the bioburden. Preliminary results confirmed the efficacy of the UVC air sterilisation devices.

UVC air sterilisation devices

There are a number of UK manufacturers of UVC air cleaning devices. The UVent was recommended for use within our acute sites as it has already been reviewed by colleagues from Liverpool. The UVent is a small mobile unit operating at 250 nm with an air volumetric flow capacity of 180m^3/h (standard) and 360m^3/h (boost). Mansfield Pollard claim a sterilisation rate of >97.6% within a 50-80m^3 environment, citing validation work at the Universities of Leeds and Bradford, and Public Health England at Porton Down.

UVC air sterilisation devices within a ward setting

Seven UVents were introduced onto the SARS-CoV-2 ward within Withybush Hospital, West Wales. The UVC sterilisers were strategically placed within each of the single occupancy, four bed and five bed areas with overall room volumes of less than 50m^3.

During the course of the pandemic, Ward 12 has been used as the main SARS-CoV-2 ward for the hospital site and has included a number of acutely unwell SARS-CoV-2 respiratory patients. See box (above, left) for the initial feedback from the local clinical teams.

Assessment

Quantifying the rate of far-UVC viral inactivation within a general room is complex and multi-physics in nature. The judicious application of CFD modelling to the understanding of the complex anisotropic air flows associated with fixed and moving objects (including humans) can suggest effective optimisations of ACH strategies achieved by combining air scrubbing with pre-existing HVACs.

Our CFD models provide information on the dispersion of airborne particles in healthcare environments where AGPs present a significant risk. CFD is a useful tool to understand the dynamics of infectious particles through the air. It has been used successfully to study the effect of different ventilation regimes, and layouts within clinical areas.

A CFD expert group was established to model the flow dynamics within a dental treatment room in Birmingham Women's and Children's NHS Foundation Trust (Prof Tony

Fisher, Royal Liverpool University Hospital; Prof Paul A White, Cambridge University Hospitals NHS Foundation Trust; Fred Mendonça and Pawan Ghildiyal, Open CFD Ltd; Peter Bill, Birmingham Women's and Children's NHS Foundation Trust; Claire Greaves, Nottingham University Hospitals; and Prof Chris Hopkins, Hywel Dda). This high-risk AGP environment was taken as a surrogate of the endoscopy suite which is the focus of this study (vide supra).

Computational fluid dynamics modelling

CFD in the engineering sciences of buildings is well established. Solving the Navier-Stokes equations governing continuum air movement, combined with the discrete particulate transport, gives us a compete view of complex ensemble of turbulence, buoyancy, aerosol dispersion, evaporation and wall interaction across the full range of particle sizes of interest, notionally [0.1 .. 100 µm³].

In this study of indoor ventilation, sponsored by UK Research and Innovation, using fully ISO9001:2015 QA'ed open-source CFD, the efficacy of several ventilation strategies was assessed. The strategies include mechanical (controlled by the building air-management system), natural (opening window), augmented ventilation (from UV air-cleaning devices) and several roof-diffuser vent designs.

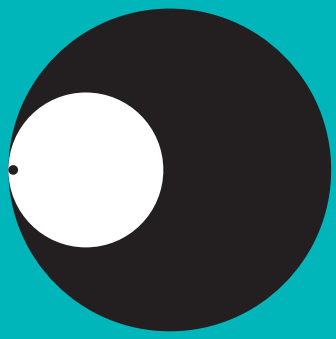
CFD tracks the age of the air (AoA) from a fresh source to anywhere within the room volume, therefore identifying which parts are well ventilated, and conversely, locations of dead air or recirculating bubbles. Mean AoA then becomes a meaningful measure of clean air circulation in the enclosure.

A CFD model of Birmingham Children's Hospital's 44.7 m³ fully-equipped dental treatment room comprises three occupants: dentist, patient and nurse. Roof ventilation slightly offset from directly above the treatment chair was supplied in the centre of the room at 5 ACH with balanced extraction to one side.

The principal mitigation within the room (before the UVC steriliser) was the number of ACHs. The modelling confirmed the clearance time one would expect of a ventilation unit running at 5 ACH (circa 10 minutes).

FAST FACTS

WEEKLY HOSPITALISATIONS IN THE SECOND WAVE



4232
9 January 2021

2037
17 December 2020

122
1 September 2020

It is noted that the current HTM03-1, which is the specification for ventilation in UK hospitals, recommends 10 ACH for treatment rooms and that the selected dental surgery room at Birmingham was only capable of delivering 50% of this target. This issue is relevant across many trusts and health boards that have old established facilities constructed before the current HTM03 was issued. Measurement of airflow rates will confirm which areas achieve current standards and which fall short and should be upgraded. It is further noted that the requirements of HTM03 are not retrospective.

Operating the room at 5 ACH means that dilution of viral load will take longer, and consequently a fallow period has had to be allowed between procedures

"WHEN THE UVC STERILISER WAS INTRODUCED, IT REDUCED FALLOW TIME BY UP TO 75%

❶ UVent mobile unit with filter - section

to give time for ventilation to change the room air to a satisfactory "clean" level.

Fallow means dormancy or latency; in dentistry, fallow time is also referred as settle time or the stand-down period.

In order to reduce the requirement for the long fallow periods (typically 20 minutes, which essentially limited the number of patients that could be seen in a clinical session) it was necessary to introduce measures to raise the "equivalent" air change rate from the current 5 ACH to over the minimum 10 ACH, as stated in HTM03.

This was carried out by installing a mobile UVC unit into the room which provided 7 ACH of recirculated air leading to a total "equivalent" of 12 ACH – i.e. 5 ACH of outdoor air supplied by the mechanical HVAC system and 7 ACH of recirculated and clean/sterilised air supplied by the UV mobile unit.

When the UVC steriliser was introduced into the room, there was a reduction in fallow time by up to 75%. On standard settings ($180m^3.h^{-1}$), the age of air within the room reduced to six minutes; on the purge or boost ($360m^3.h^{-1}$) setting, this was further reduced to four minutes.

Similar studies in well-ventilated rooms of different sizes and ventilation strategies suggests a close link between the ventilation rate (ACH) and mean AoA as an absolute measure in minutes. Positioning of UVCs or direction of airflow gives only +/-15% variation in the clean air mixing.

Conclusion

CFD modelling suggests a significant improvement in "clean air" after introduction of the UVC sterilisers, and early work with the PCR detection method for SARS-CoV-2 seems to confirm this. The improvement is seen in both AoA and "air mixing" when placed in an optimum position, with no significant issues raised from real-world testing. There is ongoing work to develop guidelines for using portable air cleaning devices in a range of clinical settings.

RECOMMENDATION

- Clinical teams should consider the use of UVC air sterilisation devices as a strategy to reduce airborne transmission of SARS-CoV-2.
- Given the rapid proliferation of UVC air sterilisation devices on the market, technical and safety standards will be required to ensure that the manufacturers conform to fundamental safety and efficacy principles.
- The Working Group will develop technical and safety standards for the UK.

***Professor Chris Hopkins**, Head of Clinical Engineering, Hywel Dda University Health Board. **Professor Tony Fisher**, Head of Department, Medical Physics and Clinical Engineering, Royal Liverpool University Hospital. **Professor Paul A White**, Consultant Clinical Scientist and Head of Clinical Engineering, Cambridge University Hospitals NHS Foundation Trust. **Fred Mendonça**, Technical Experts Director, Innovation and Discovery, Managing Director, Open CFD Ltd. **Pawan Ghildiyal**, Senior Engineer, Open CFD Ltd. **Peter Bill**, Consultant Clinical Scientist, Head of Department, Department of Clinical Neurophysiology Birmingham Women's and Children's Hospital. **Claire Greaves**, Chief Scientist and Clinical Director for the Science and Technology Pathway, Nottingham University Hospitals. **Frank Mills**, Chartered Professional Healthcare Engineering Specialist, Member of Institution of Mechanical Engineers COVID Task Force.*

Ahead of her talk at the Medical Physics and Engineering Conference 2021, **Angela Douglas MBE**, Deputy Chief Scientific Officer for NHS England and NHS Improvement, pays tribute to the workforce.

MPEC 2021

Why this matters to me

The sheer volume and complexity of medical equipment in the NHS has grown rapidly in recent years and will continue to do so. As we move into an NHS that is health-tech driven, the importance of tech in the delivery of clinical services is being recognised in the NHS Long Term Plan.

Medical physics in its application in patient care, and clinical engineering in the provision and support of medical and patient equipment in healthcare, covers everything from direct care and equipping hospitals and health facilities, to the development of devices and techniques and the delivery of high-quality healthcare in the community. The medical physics and chemical engineering (MPCE) workforce underpins most NHS diagnostic and critical treatment services.

Indispensable roles

This year, the MPCE professions have really stood up to the challenge, "breaking through barriers" – which is the theme of this year's Medical Physics and Engineering Conference (MPEC) – by going above and beyond. Not only supporting equipment through its lifecycle, providing rehabilitation and community services, and advising on risk and compliance with regulation, but also carrying out horizon scanning, introducing new technologies into clinical practice and optimising systems for equipment support. They have done this in times of unprecedented adversity, and

WHEN THE NHS WAS HONOURED BY THE QUEEN WITH THE GEORGE CROSS, OUR MEDICAL PHYSICISTS AND CLINICAL ENGINEERS WERE AT THE HEART OF IT

with extraordinary teamwork, playing indispensable roles in helping the health service to look after many hundreds of thousands of seriously ill patients with COVID-19. When the NHS was honoured by the Queen with the George Cross, our medical physicists and clinical engineers were at the heart of it.

During the pandemic, clinical engineers in particular have mobilised across their regions to respond in this fast-moving, rapidly changing environment.

They have designed vital new PPE, provided solutions for taking of temperature accurately and safely, sanitised, and decontaminated vital equipment so that it could be redeployed at speed and provided solutions for sanitising ambulances and even the air in our rooms and clinical areas, such as dental clinics.

We all know about the Nightingale Hospitals and the support this workforce provided there, but they have also used their unique skills to ensure every NHS hospital could function at times of surge capacity efficiently and effectively. More recently they supported the deployment of oximeters, as part of the "Virtual Ward" initiative to look after individuals with long COVID at home, and the deployment of monitors as part of the NHS@Home initiative. They have been a vital part of the design, development and roll-out of COVID-19 mobile testing units (vans and trailers), working with Directors of Public Health, providing vital testing in outbreaks, offering early warnings of potential variants of concern. And, when we finally return to some level of normality, our clinical engineers will also be key in the recovery of our NHS services, and are already supporting the return and restoration of diagnostic and other clinical services.

We have had a truly exceptional response from this workforce, and I have had the honour and privilege to chair the National Clinical Engineers Network, with representation from across the UK, on a weekly basis. Working together to provide support, share experiences and offer solutions to some of the most critical problems and incidents our NHS has faced this past year.

Our National Network is collating and sharing these lessons learnt.

Inspire the next generation

We also need to ensure we are growing this workforce and working to deliver a flexible training framework to ensure we can recruit enough of the right people at every level, providing this workforce with career progression and succession planning, and making the NHS the best place for them to work. We need to inspire the next generation of medical physicists and clinical engineers, and are working with STEM, professional bodies such as IPEM, and even the Science Museum to raise the profile of MPCE, without whose contribution we would have been in an even more critical place through this pandemic.

I would like to take this opportunity to thank each and every one of our medical physicists and clinical engineers for everything they have done in this past year, for breaking the barriers and showing us the art of the possible, and for the incredible work they continue to do. This is a workforce the NHS should be so proud of – I certainly am.

Turn to page 26 for more information on MPEC 2021. For programme updates, further information and to register, visit ***ipem.ac.uk/ConferencesEvents/MPEC.aspx***

BREAKING THROUGH BARRIERS

We take a look at the Medical Physics and Engineering Conference (MPEC) 2021, which is taking place online from 21 to 23 September.

The theme for this year's conference is "Breaking through barriers" and IPEM is excited to bring this event to our communities, with a focus not only on our scientific endeavours within the industry, but a wider wellbeing remit, too.

Thought provoking

The programme includes a range of informative, entertaining and thought-provoking sessions with some outstanding guest speakers. You can hear about clinical entrepreneurship and innovation with Professor Tony Young, National Clinical Director for Innovation NHS England and Founder of the Clinical Entrepreneur Programme, or register to attend "Emerging technologies in cardiovascular disease" with Jonathan Mant, Professor of Primary Care Research and Head of the Primary Care Unit at the University of Cambridge. We are delighted that we will be joined by Angela Douglas MBE, Deputy Chief Scientific Officer, who has recently received an honorary fellowship from IPEM.

The workplace

We are also pleased to say that we are offering a range of sessions on wellbeing and are delighted to welcome Carrie and Clark Carlisle to the event to talk about lived experience of mental health.

We will be offering a session looking at autism in the workplace, delivered by The Curly Hair Project, and a session on "Improving diversity in our sector", which includes Anna Barnes, Director at King's College London, Technical Evaluation Centre (KiTEC) and IPEM Trustee Lead on Equality, Diversity and Inclusion.

There will be sessions covering outreach, with guests including Holly Ellis – the Scouse Scientist, and our annual prize giving, which will honour the recipients of both the Martin Black and the Robert's Journal Prizes.

Register now

Registration is now open and registered delegates will be able to access all the content on demand after the event, so you don't need to miss a thing.

For trainees there is the chance to receive one-to-one feedback on your presentation from senior members of IPEM, which is a fantastic CPD opportunity to take advantage of. Abstract submission for Trainees only will be open until early September – contact **conferences@ipem.ac.uk** if you would like to be considered.

After such a difficult year we are really looking forward to this annual event, and with a new events platform offering additional networking and exhibitor opportunities, we hope you will join us there. Further details are on our website: **ipem.ac.uk/ConferencesEvents/MPEC.aspx**

COACHING

A tonic for your thoughts pt. 2

Andy Nevill presents the case for coaching and shares some personal insights in the second of a three-part series.

This is the second of three articles in a mini-series that aims to provide an introduction to coaching and how it might be used to good effect in the workplace. In part one, I offered a definition for both coaching and mentoring (see figure ❷ and ❸), and compared and contrasted these two learning interventions. I then took a brief look at the evidence base and explored how the way we think affects our feelings and behaviours. For this second part, I describe the coaching process and identify competencies for effective coaching. I then present a model for a coaching toolbox and describe the first section of this toolbox: process tools for the coach.

In part three, which will be published in a future issue, I will complete my description of the toolbox, which contains useful resources for the coach to draw upon to support their client. There are clearly numerous opportunities for healthcare scientists and I offer some practical suggestions and five recommendations. Finally, I will round off with a synopsis of my own journey, which I will link to my recommendations to provide a personal reflection.

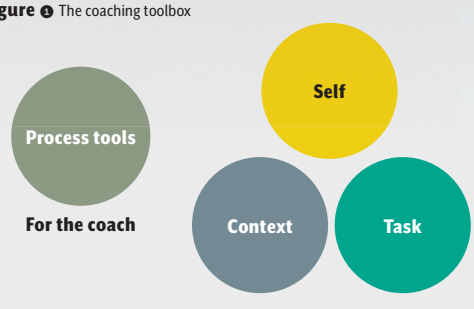
Process

We all coach, perhaps not deliberately. Coaching can occur in a five-minute chance conversation. Taking a coaching approach to your work and coaching as a line manager, however, involves the use of specific tools and techniques as and when appropriate. Organised workplace coaching is more structured and would typically consist of four to six sessions of 90 minutes contact time over a period of around six months. This would be carried out within the framework of an agreement.

The relationship between coach and client will differ depending upon the situation, and balance of power will influence this in a line management setting. For some situations coaching would not be appropriate – behaviourally incompatible individuals are not going to work on their issues, even with the best, most expensive business coach.

Line managers may choose to adopt a coaching approach, but also have access to numerous organisational processes for dealing with various workplace and workforce situations.

Figure ❶ The coaching toolbox



IMAGES: GETTY

Structured workplace coaching involves initial contact, contracting, a number of coaching sessions and some form of evaluation. What may be referred to as a "chemistry session" is usually arranged for the coach and a prospective client to initially meet. The very first contact is critical as this is where the coach is able to start developing rapport. Unconscious human instincts are at work: Is it/am I safe? Do I have the resources to deal with this situation?

This is also the point at which the contracting process commences, which aims to ensure that the coaching relationship agreement is understood by all parties. This is an agreement between the coach, the client and sometimes a third party – usually the client's employer. Responsibilities for all involved and practicalities of the coaching programme are described and any known goals and objectives are captured. Confidentiality, data protection and complaints would also be covered.

Figure ❷ Interpretation of coaching, sitting between training and mentoring

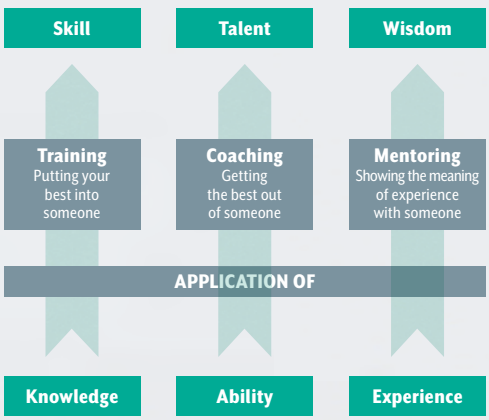
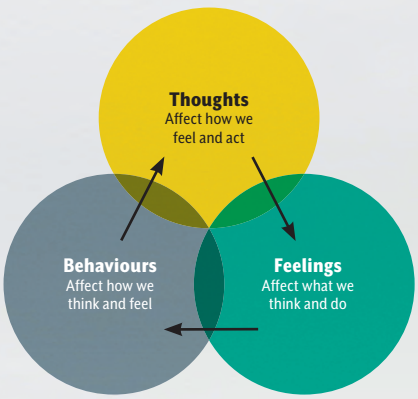


Figure ❸ The cognitive triangle



If agreeable, the coaching programme would then commence and the client would commit to action, which is identified from session to session. It is important to understand that the decision to act comes from within. After the final session the client has the opportunity to capture outcomes and identify next steps for their own development, and would also be invited to complete an evaluation of their experience.

A coach working professionally, or as part of an organisational workplace coaching offer, will adopt a continuous learning approach to their work and will seek out opportunities for their own personal development and coaching supervision.

> **"CLIENTS ARE ON A JOURNEY OF DISCOVERY AND THIS DISCOVERY BELONGS TO THEM**

Competencies for coaching

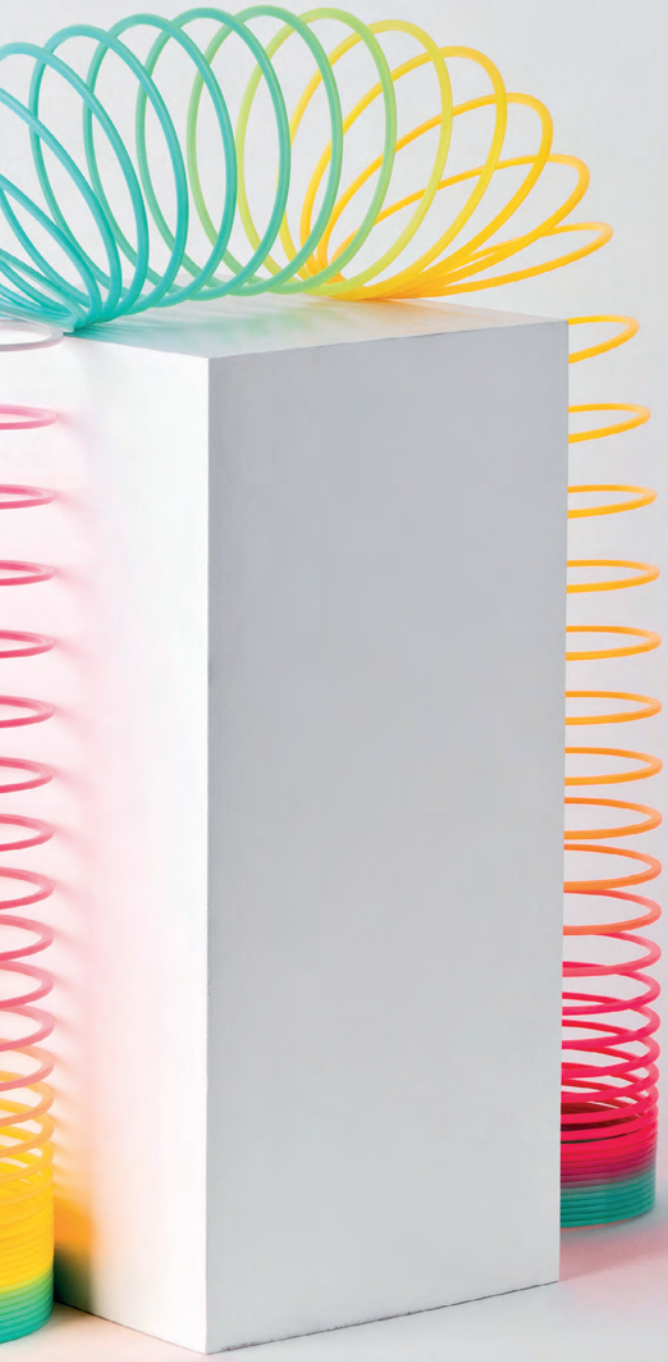
The Association for Coaching has published a competency framework and a code of ethics that set out the skills and behaviours required for their members.

A coach will need to be proficient in the following:

- **Listening.** A genuine interest in what their client is saying is required. This requires active listening skills and the ability to be attentive and curious. The coach needs to be able to listen with ears and eyes to really take in what is being said, reading non-verbal language and emotion alongside verbal language to do so. The client will set the agenda and will do most of the talking while the coach will set the pace and interact as described below.
- **Reflecting.** The coach will need to be able to effectively reflect back to their client what s/he has heard. This illustrates that the coach has really listened, and it enables both parties to check and validate what has been said. Techniques for this include paraphrasing and reframing, summarising and repeating meaningful words. Using the client's name can also have a powerful positive impact.
- **Questioning.** "Question everything," Albert Einstein said. Questioning is a critically important skill that deepens the learning of the client and moves them towards a goal. The coach will need to be able to ask relevant questions and be mindful of different types and their purpose. Questions should be short, typically seven words or less, and open rather than closed.
- **Challenge and perspective.** The coach will need to be able to challenge the client while also maintaining the relationship, and judge when to do so. Playing back contradictions can be a good way of challenging. The coach will also need to be able to help the client explore

different perspectives, particularly if the client is getting stuck in a particular perspective.

- **Provide feedback.** The coach will need to be able to provide feedback to support development. Feedback needs to be timely and competently delivered. It should be clear, relevant, non-evaluative, helpful and constructive.



- **Being supportive.** It is important for the coach to be able to build rapport and trust with their client and the ability to support and encourage could make the difference between keeping going and giving up.
- **Accountability.** The coach will need to be able to hold their client to account for any actions that the client agrees to progress. If a client commits to action and knows that they will be held to account, there will be strong likelihood that progress will be made.
- **Focus on the client.** Clients are on a journey of discovery and this discovery belongs to them. The coach is there to facilitate this discovery for the client and to help them make sense of the situation they find themselves in. The coach has no agenda: this is set by the client. The coach also needs to be able to suspend judgments, opinions and prejudices. The coach will hold their client in unconditional positive regard and will focus 100% on their client and their agenda.

The toolbox

Figure 1 is a visual representation of the coaching toolbox, which can be usefully divided into two sections: one for the coach to support them in the coaching process itself, and one containing resources for the coach to discover, share and use with clients. For the first section, a whole range of tools are available for the coach to guide and support the process. The challenge for the coach is choosing what to use, and particularly so for someone new to coaching.

The GROW model provides a good structure for a coaching conversation or session and is one of the most common coaching tools. Figure 2 shows my own interpretation of this model, which consists of four stages. There is some logic in moving through the four stages sequentially; however, the model should not be seen as a strictly linear process and it is quite acceptable – and indeed typical – for a conversation to cycle through and jump around the model.

Andy Nevill *is a Consultant Clinical Scientist and Interim Head of Medical Physics at Royal Devon and Exeter NHS Foundation Trust. For references to accompany this article, email rob.dabrowski@redactive.co.uk*

Figure 2 The author's interpretation of the four-stage GROW model

COACHING WITH THE GROW MODEL

GOAL

What would you like to achieve?

- Explore topics for discussion
- Agree objectives for the session
- Identify longer term and nested goals

REALITY

Where are you now?

- Explore the current situation
- Invite self-assessment
- Focus in on what is relevant
- Discover resources and barriers

OPTIONS

What are your options?

- Investigate solutions
- Look at all the options
- Focus in on what is possible
- Make choices

WILL DO

What will you choose to do?

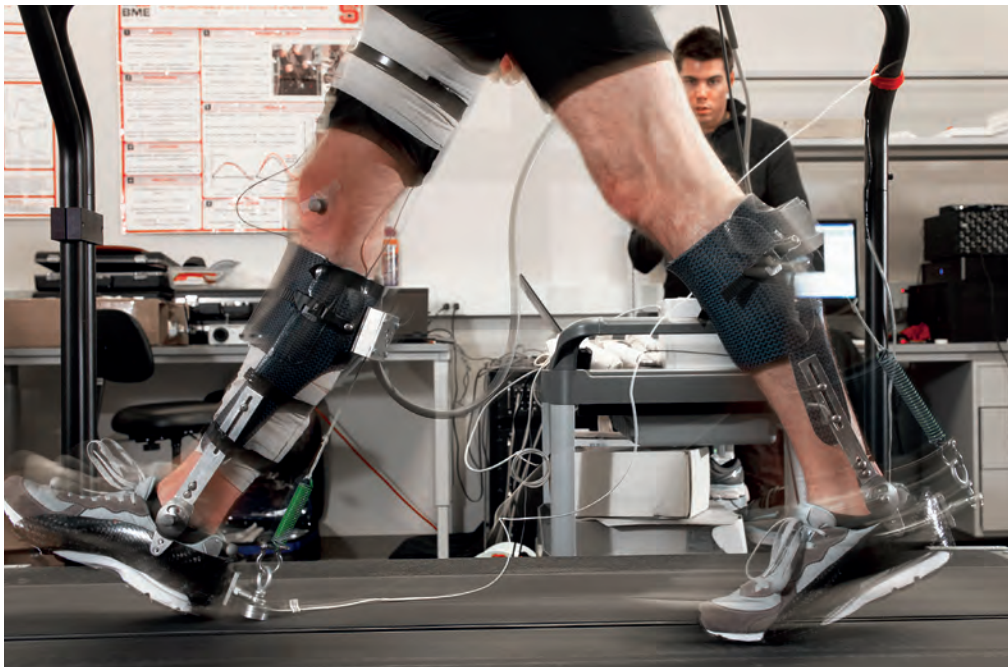
- Commit to action
- Timing and resources
- Identify support required
- Check back to goal

IPEM 2025

Delivering growth

IPEM's new strategy for the next four years has been published. Here we look at the some of the key content.

Professor Stephen O'Connor, IPEM President, provided the foreword for the new strategy, which gives an overview of the Institute's direction of travel of the coming years. He wrote: "Growth of the professional development activities of our members and the impact of our scientific leadership is the cornerstone that will drive our operations. In our strategy, you will see how we are planning to deliver that growth. We shall simplify IPEM's range of activities by focusing on what really matters, that is working in the public interest to support and maintain standards and practice development across our professional community. It will guide how we allocate our resources, bring together the charitable, professional, learned society and commercial elements of the organisation, and align the efforts of both staff and volunteers.



"In this strategy document, we shall explore the three major roles that our Trustees have endorsed, namely professional development, community and leadership. You will also get an insight into IPEM's new brand. Uniting these complementary elements is an evolved set of values developed alongside members, which support our updated mission and vision for the future. This is the beginning of a range of exciting developments. Next steps include a refreshed, long-term plan for our journals, a strategic approach to knowledge management and a new IPEM website. As we take time to reflect on the tragedy of the pandemic emergency, which will shape our professional and personal lives for years to come, this strategy also seeks to support IPEM members as the disruption continues. Months of staff and volunteer time has been dedicated to developing this exciting progression for our organisation.

I would like to thank everyone involved for bringing it about. I commend this strategy to you and look forward to IPEM's continued growth and success."

STRATEGY

IPEM's focus will be on:

Professional development

Providing excellent learning and development services that meet the needs of the professional community of physicists, engineers and technologists working in physics and engineering in medicine and biology in hospitals, academia and industry.

Community

Growing and nurturing a vibrant community of practice through our membership, with high professional standards at its core, outstanding volunteer engagement and a real commitment to equality, diversity and inclusion.

Leadership

Championing the importance of professional knowledge and innovation, identifying and raising awareness of the key challenges that lie ahead for physics and engineering in medicine and biology, and being a trusted and effective voice for the profession.

PROFESSIONAL DEVELOPMENT

IPEM will support the professional community through the provision of professional learning and development, and valued scientific meetings, supported by robust, credible and respected workforce data. IPEM aspires to be a 'quality mark' in education, the end point assessor of choice, and an innovative and excellent provider of education, training and research events as well as an influential voice in workforce policy. IPEM's strategy is to:

- Offer a comprehensive and accessible range of inspiring and high-quality learning and development opportunities encompassing: scientific research, professional knowledge, professional development, community networking, and leadership
- Raise our profile as a provider of learning and development
- Grow our visibility and value as an accreditation service
- Invest in an online e-learning platform that can widen access to training and increase throughput
- Collect and deploy workforce intelligence and wider training data to deliver greatest impact.

What will IPEM do?

- **Strengthen and promote Route 2/Part II & Clinical Technologist Training Scheme**
- **Become accredited as an End Point Assessment Organisation (EPAO) by September 2021**
- **Position IPEM as EPAO of choice with employers**
- **Facilitate access to the training pathways to registration for both clinical scientists and clinical technologists, growing numbers in training, the workforce and membership and underpinning the value of membership**
- **Use accreditation links with higher education institutes to promote Route 2/Part II directly from MSc and MEng exit points**
- **Accredit educational modules against ULAF required to uplift from BSc Physics/Medical Physics to access Clinical Technologist Training Scheme**
- **Utilise the new IPEM website and e-learning platform to go further in meeting the needs of the workforce, and develop a high-quality research scientific programme shaped by horizon scanning.**

> "THE AIM IS TO BUILD THE 'GO TO' PROFESSIONAL COMMUNITY WHERE EVERYONE CAN PARTICIPATE

COMMUNITY

IPEM's members and volunteers are fundamental to the delivery of IPEM's charitable objective. IPEM must not only recruit, but inspire, develop, support, motivate and retain them. The aim is to build the 'go-to' professional community in medical physics and clinical engineering, living by our values to create a community where everyone can participate, and a culture of respecting diversity. IPEM's strategy is to:

- Seek to improve the membership experience and how we present and deliver the benefits of membership

- Focus on providing a community of practice, with high professional standards at its core, and engaged and inspired volunteers
- Strive to remove barriers to inclusion and participation within IPEM and in the wider STEM community.

What will IPEM do?

- Grow IPEM's membership through recruitment and retention, including: Launching a 'recommend a friend' campaign; working with our members to capture our Member Value Proposition (MVP); delivering diverse, regular, memorable and reciprocal engagement and communications with our members
- Provide a working infrastructure for a professional community of practice, including mentoring, by: growing new member groups and stronger links between the special interest groups and the communities of interest; reinvigorating our mentoring programme to support members in achieving their goals, whether that is registration, the next level of IPEM membership, career progression or other
- Become synonymous with raising the profile of professional registration by: effective IPEM-led communication and marketing of the value of Science Council, Engineering Council and RCT registrations
- Demonstrate IPEM's commitment to EDI across all activities by: developing an EDI action plan based on the Engineering Council/Science Council Framework; improving IPEM's EDI data collection wherever possible; supporting accessibility and inclusion in STEM and in a wider social context; ensuring IPEM develops and maintains a culture of accessibility and inclusion
- Provide outstanding volunteer support by: a new induction programme and emphasis on recruitment and retention including video introductions; improved channels of volunteer communication and high-quality information provision
- Deliver an impactful outreach programme by: aligning outreach with EDI to deliver activities that address social mobility; ensuring we have the required equipment and materials available to facilitate member participation; recruiting volunteers for larger events and promote/support national initiatives
- Increased promotion of CPD as a key member value by: placing greater emphasis on 'reflective learning' rather than timetabled training; Promoting MyCareerPath as a valuable tool for recording CPD.

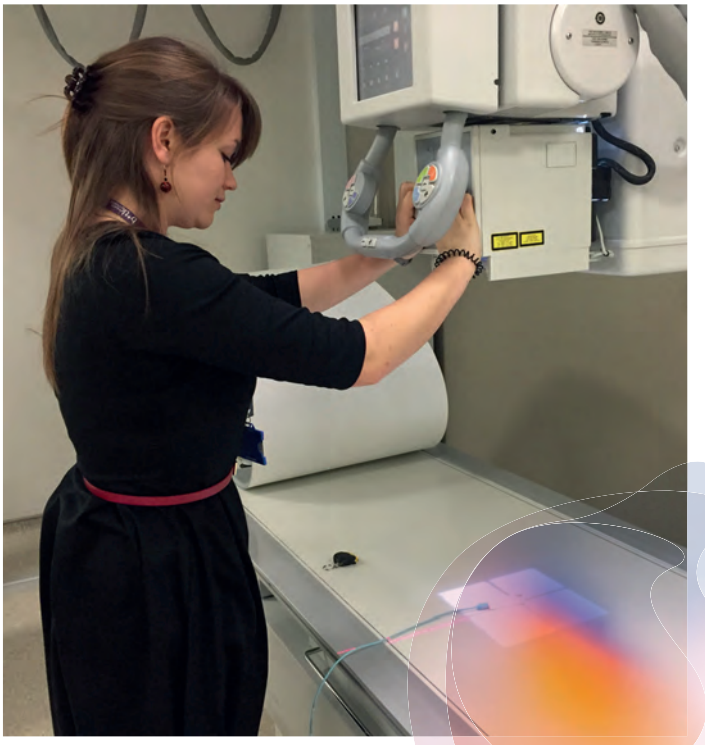
> "IPEM WILL EMPHASISE THE IMPORTANCE OF PROFESSIONAL KNOWLEDGE AND INNOVATION

LEADERSHIP

To deliver leadership in healthcare science, IPEM will emphasise the importance of professional knowledge and innovation, identify and raise awareness of the key challenges that lie ahead for physics and engineering in medicine and biology and be a trusted and effective voice for the profession. Integrated, impactful communications and marketing will support the delivery of ongoing leadership aims, and will underpin our work in offering our members the professional development services they need and grow a genuinely collaborative community of interest and practice.

To boost IPEM's visibility as a leader in the wider context of healthcare science, IPEM will emphasise professional knowledge and innovation and will be an effective voice for the profession. IPEM will achieve this through:

- Reputation and relationship management, engagement and communication
- Knowledge management and the development of intellectual capital. Understanding and communicating the future operating environment for MPCE professionals



- Unlocking the potential of our members to shape the future of their profession.

What will IPEM do?

- Develop a 'Futures' agenda for physics and engineering in medicine and biology that encompasses horizon scanning, identifying the key challenges and drivers of change, and the development of professional knowledge and innovation
- Raise IPEM's profile and increase impact through leadership of national and international dialogue and initiatives in medical physics and clinical/biomedical engineering
- Anticipate, understand and address future changes in the operating environment for members in medical physics, clinical/biomedical engineering, academia and industry, raise awareness of IPEM's role in delivering this
- Improve the quality and quantity of high-value resources produced (such as professional standards, guidance, reports, briefings and events) for members and stakeholders, and communicate them effectively
- Identify and promote new opportunities for learning and development programmes and other potential commercial services
- Support innovation and professional development through delivery and promotion of IPEM awards, prizes, grants and bursaries, ensuring they reflect the agenda for research and development
- Enhance science communication efforts through sharing knowledge-based content and providing expert opinion
- Be a recognised advocate for the profession and a trusted source of information and comment
- Influence relevant public policy and law
- Promote careers in our sectors and espouse the values of professionalism
- Support outreach activity across the UK, aligning it with our EDI agenda to target 'hard-to-reach' communities.

NEXT STEPS FOR 2021 AND 2022

Journals strategy

IPEM's publications are a vital resource for members and non-members alike. IPEM's e-book programme with publishers IOPP continues to grow, while our four international, peer-reviewed journals enable access to the very latest research. A new journals strategy will aim to reinforce and extend that position, while ensuring our journals are flagships for physics and engineering in medicine, and publications within which any researcher is proud to publish.

New IPEM website

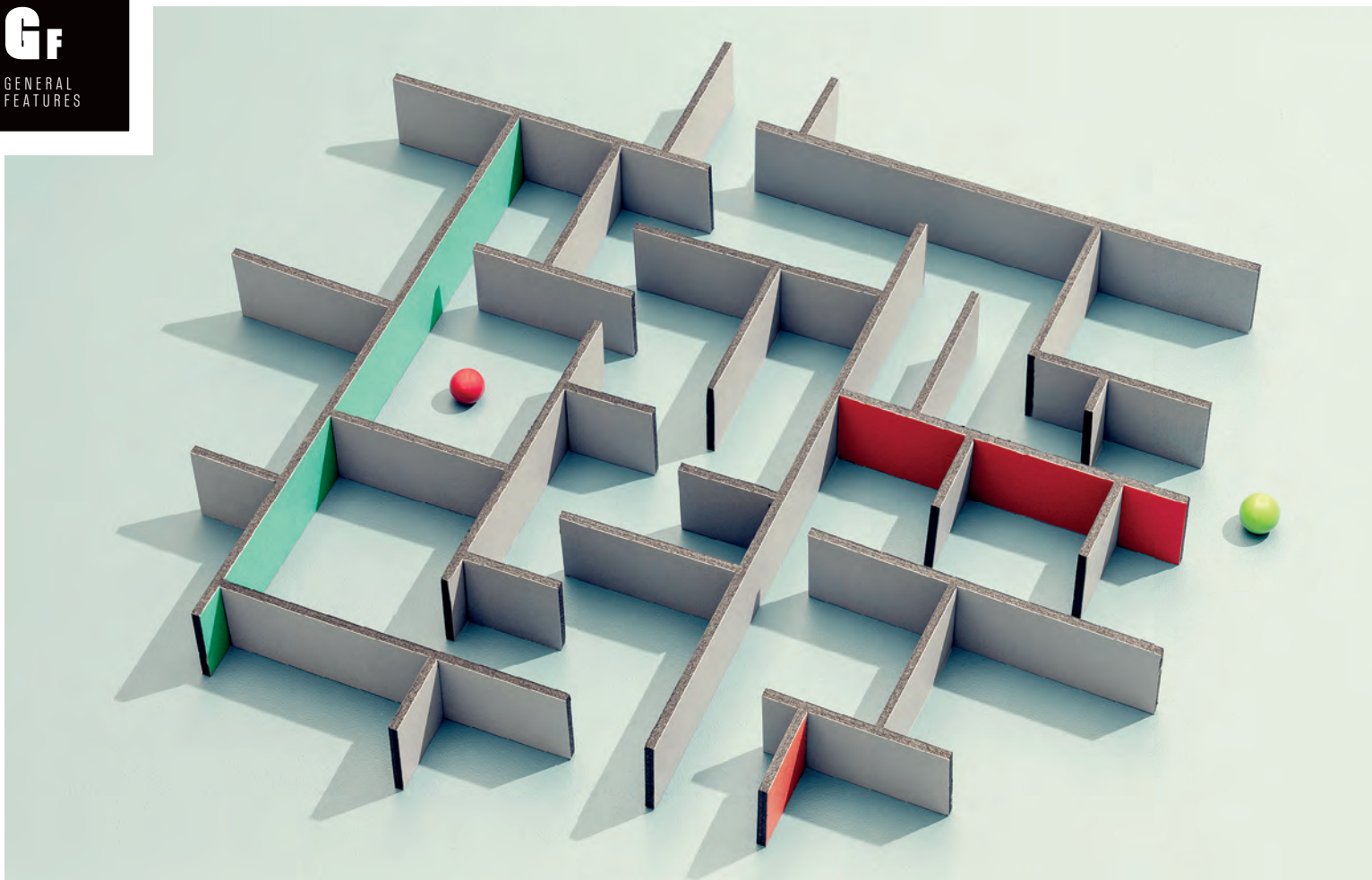
A completely reimagined online presence, optimised for use across all devices, it will encompass membership tools, active communities, a range of resources and a compelling showcase into what our members do and why it matters.

Science strategy

IPEM is committed to developing a 'Futures' agenda for physics and engineering in medicine and biology, which encompasses horizon scanning, identifying the key challenges and drivers of change, and the development of professional knowledge and innovation.

To help deliver our new science strategy, IPEM has appointed its first Professional Knowledge and Innovation Manager. With experience of the full development lifecycle of medical devices and in vitro diagnostics, from benchtop development to pilot plant and full-scale manufacture, she will bring a creative and analytical approach to broaden understanding of the range of activities within IPEM's membership, with an eye to identifying future trends in medical engineering and physics.

To read the full report online, visit ***ipem.ac.uk/AboutIPEM/IPEM2025.aspx***



EQUIPMENT TRACKING AND COVID-19

Specialist Clinical Engineer **Stuart Barton** explains how a radio-frequency identification system helped meet the challenges of the pandemic.

In April 2019, the Chesterfield Royal Hospital created a wholly owned subsidiary to provide a managed facility for the rest of the hospital. This meant Derbyshire Support and Facilities Services (DSFS) was now responsible for the hospital's estate and equipment.

In clinical engineering we saw this as an opportunity and a challenge:

- How could we better manage the medical equipment on site?
- How could we go about improving our maintenance targets?
- And how could we improve the service we offered to the Chesterfield Royal Hospital?

❶ New Drager ventilators – the trust hired/loaned 211 extra devices during the pandemic and purchased many more

Installing a radio-frequency identification (RFID) system in the trust had been a long ambition of the department but had always been seen as an expensive development. However, with advancements in technology and the new opportunity the forming of DSFS presented us, the prospect of installing an RFID system started to become a reality.

After installing Idox's iFIT solution, the aims of the installed RFID system were to:

- Provide a safer patient environment
- Help the trust locate critical equipment, aid patient care and better facilitate patient flow – especially during periods of high demand
- Improve the quality of the service we provide to Chesterfield Royal Hospital
- Identify where equipment is immediately to help facilitate the Medicines and Healthcare Products Regulatory Agency (MHRA) alerts and manufacturers' upgrades
- Better manage equipment on hire, loan and rental.

A priority list of equipment was identified, and equipment from across the trust including the equipment library, bladder scanners, ECG recorders, and beds were found, tagged, and added to the system.

However, the pandemic arrived and brought not only changes to how we went about our daily lives, but also new challenges in how we went about our jobs as clinical engineers. This is when iFIT stepped up to great effect and became an invaluable tool.

"IFIT'S SMARTMAP ALLOWED US REMOTE ACCESS WITHOUT THE NEED FOR PPE"

Controlling limited resources across multiple critical care units

Work started on Chesterfield Royal Hospital in the late 1970s and opened in 1984. It consists of 500 acute adult beds, with seven intensive care unit (ICU) beds and eight in a separate high dependency unit (HDU). Despite the units being relatively close in location to each other there is no direct access from one unit to the other. So, when the pandemic began it was relatively simple to convert the HDU into a COVID-19 ICU, while continuing to treat the non-COVID-19 critical care patients in the ICU.

However, as the number of patients with COVID-19 increased, inevitably the decision was taken to increase the critical care capacity by creating a second COVID-19 ICU. This is where our challenge began.

Critical care had to expand – we needed more critical care beds and although we were trying to place orders for more equipment, so was every other care centre in the world. With only the resources at our disposal:

- How could we expand?
- How could we start to equip extra areas to accommodate the influx of critical care patients?
- And when it was all over, how could we make it easier to return every piece of equipment back to its original location?

The answer was the equipment-tracking system. Although our plan was to eventually place RFiD tags on all the medical equipment in the trust, the majority of the equipment in critical care and theatres had not been on the original priority list.

We found ourselves in a race against time, speedily tagging all the equipment so that we could identify where on site the equipment was located at the press of a button ❷.

With access to some areas becoming restricted, iFIT's SMARTMAP allowed us remote access to the restricted areas without the need to put on full personal protection equipment (PPE) ❸ and physically enter these areas unless we absolutely needed to.

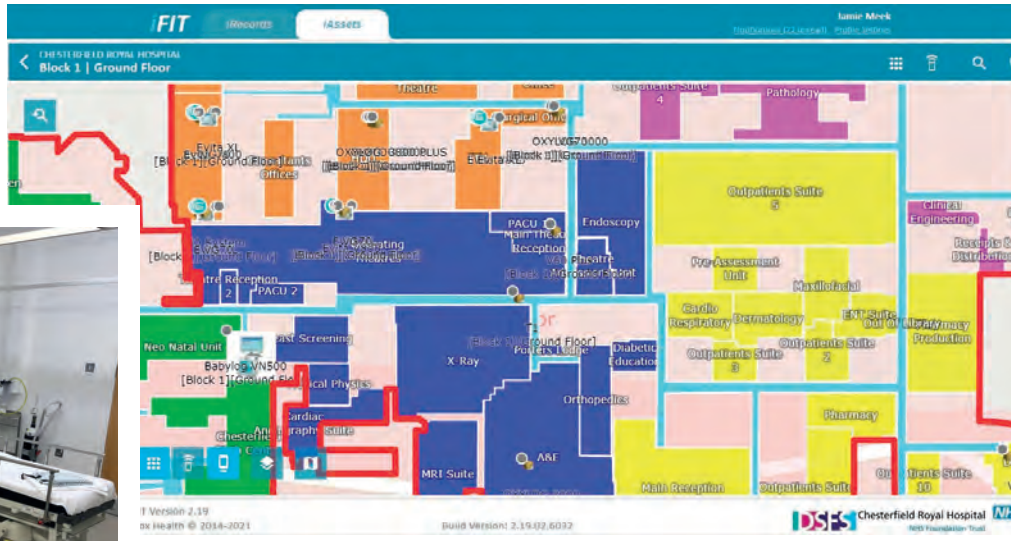
We soon found the role of the RFiD system expanding into areas we had not initially considered. The initial plan for iFIT was for it to be used to find medical equipment around the trust. In March, the pandemic had led to another issue – PPE.

With a global shortage of PPE, especially respirators, we were approached by the DSFS Health and Safety Management team. In order to mitigate the risks of non-availability, they urgently needed to keep track of the small number of respirators they had managed to obtain.

Never a department to turn down a challenge, we set to work searching for and locating all the respirators and accessories on site, then tagging and uploading the equipment into the software. This meant we could locate the position of the respirators in the hospital with a few clicks of a mouse.

IMAGE: GETTY

❸ Idox's iFIT SMARTMAP showing the locations of the ventilators on site



❷ Extra stretchers were set up in our emergency department. The extra equipment was fitted with an RFiD tag to help keep track of it

Recovery and restoration

By the end of April, the first wave of the pandemic was slowly coming to an end and the numbers of patients being treated in the hospital with COVID-19 was declining. The trust was drawing up recovery and restoration plans. For those of us in clinical engineering this meant helping restore services that had been reconfigured as part of the escalation process.

Again, iFIT allowed us to track down equipment and return it to its original locations with relative ease, instead of having to spend days walking around the hospital looking for it.

Other wards were closed, so iFIT allowed us to set flags on the software, which meant that if any of equipment was moved off these areas and passed under any of the sensors on site, we would be made aware of it.

More resources, more challenges

When COVID-19 case numbers started to creep up again, additional loan resources arrived from NHS England in the shape of extra ventilators and monitors ❶. We also received a variety of other pieces of equipment supplied by numerous manufacturers and suppliers up and down the country, all of which were fitted with specially made 'loan equipment RFiD tags'.

Even before we had implemented iFIT, we had always been keen in clinical engineering to try and keep track of equipment that is loaned to the hospital or on hire to us. This used to be a problematic and difficult task, with audits to find and trace equipment taking an engineer up to two full weeks every six months. They had to try to find the equipment or see if it had left site. Again, with the RFID system this task was reduced to just a single afternoon.

Second wave

With the number of admissions to the hospital on the rise, like the rest of the NHS, the Chesterfield Royal Hospital soon found itself under increased pressure from all sides, with patients needing COVID-19 and non-COVID-19 interventions.

With more patients being admitted compared to the first wave, and not just to COVID-19 areas, a reorganisation of the trust's services once again saw critical care and the respiratory units expand.

This meant our increased resources were once again being stretched. Like in the first wave, the hospitals site-wide RFiD system helped ease a little bit of the pressure. This time it wasn't critical care contacting us for equipment, but a variety of wards ringing and asking if we knew where their bladder scanner was or where their ECG recorder had been moved to. Thankfully, with each request the answer was given within minutes: "yes your machine was moved to ward 'X' on this date and time."

"WE DIDN'T HAVE TO SPEND DAYS WALKING AROUND LOOKING FOR EQUIPMENT"

Moving forward

Once there are no more COVID-19 waves, what does the future hold for the RFiD system as well as the hospital? What tasks will be required of the RFiD system going forward? Well, no matter what happens in the future, it is fair to say the iFIT RFID system is here to stay.

For the immediate future, when the trust starts to de-escalate its COVID-19 activities, all the equipment will need to be returned to its original locations. The additional equipment purchased for the trust will have to find a permanent home or be placed in storage. All of this will be done under the watchful eye of iFIT. In addition, all the equipment loaned to the trust – an extra 211 medical devices – will need to be recovered and returned to the companies who loaned them to us. A task that yet again will be made easier with the temporary RFiD loan tags attached to them.

When things do finally calm down we can evaluate iFIT's performance during the pandemic against the original aims of the system when we purchased it.We will be able to easily say that it met them all and that it has already repaid a big piece of the initial outlay. And without the system our roles within clinical engineering would have been made a lot harder.

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The British Nuclear Medicine Society will hold its Annual Meeting from Monday 27th to Wednesday 29th September. The meeting will be held virtually using the same online platform that debuted successfully for the Spring meeting held in May this year.

BNMS
BRITISH NUCLEAR MEDICINE SOCIETY

As usual, there have been excellent contributions from the scientific and technical disciplines in the field of nuclear medicine with 26 of the 52 oral presentations and 16 of the 37 poster presentations coming from these groups. As is tradition, the meeting will begin with a half-day bootcamp, consisting of five sessions offering educational content on topical themes. It will not have gone unnoticed that regulatory bodies are focussing more and more attention on inspections and hence one of the bootcamp sessions will provide talks from the ONR and HSE on expectations. The session will finish off with physicist Julie Speakman (Royal Derby Hospital) discussing their experiences of when an inspector calls... Continuing on the theme of inspections, physicists Bill Thomson (City Hospital) and Matthew Memmott (Central Manchester) will present a methodology review of various radiation risk assessments techniques.

The main meeting consists of two streams offering a total of 11 scientific sessions. These sessions consist of invited speakers offering their expertise and will cover a range of topics including masterclasses in SPECT-CT and PET-CT, new technologies, radiation protection, radiopharmacy, and artificial intelligence. As part of the plenary session, Andrew Robinson (NPL) will discuss traceability and standardisation and this year's annual lecture will be given by Arturo Chiti from Milan on artificial intelligence and radiomics – an area that is growing exponentially in the field. Oral presentations and posters are pre-recorded and will be available on-demand on the online platform, allowing the viewers the option to pause and rewind presentations – a luxury that has arisen in the world of virtual conferences that we are now so accustomed to. Each session will finish with interactive question and answers forum where the session chairs will take questions from meeting delegates and put them to the presenting speakers.

Ian Armstrong, Principal Physicist, Nuclear Medicine, Manchester University NHS Foundation Trust. BNMS Scientific and Education Committee

Visit **www.bnms.org.uk** for more information.

Hub tickets are available for those who wish to have the local 'conference' experience and 'listener' tickets will be available for 30 days after the event.

PROSTATE CANCER IMAGING

An alternative to PET

Is there a role for ^{99m}Tc-PSMA in times of ^{18}F-PSMA?

Prostate cancer (PC) is the second-most-common cause of death in developed countries and it is the most common type of cancer in males. Age is the most important risk factor: PC is rare under the age of 40, but its incidence increases exponentially with age. Early PC is often asymptomatic and increasingly diagnosed at routine rectal examinations.

Treatment depends on risk, usually determined by Gleason score, prostate-specific antigen (PSA) levels and imaging results.

The prostate-specific membrane antigen (PSMA) is expressed in tissues such as kidneys, proximal small intestine and salivary glands and overexpressed in PC, thus representing a highly valuable molecular marker.

Radiolabelled PSMA imaging of PC has been increasingly used in the past few years. Furthermore, labelling of PSMA with β and α emitters provided a new option in treatment of patients with PC.

PSA provides a promising target for PC imaging. Although ^{68}Ga-PSMA and ^{18}F-PSMA have been widely studied, ^{99m}Tc labelled PSMA for planar and SPECT-CT imaging appears to be a promising alternative to positron emission tomography (PET) tracers for diagnostic work-up of PC patients, being, therefore, more cost-effective.

We present a retrospective single-centre experience with ^{99m}Tc-PSMA and ^{18}F-PSMA.

Materials and methods

The data were collected between December 2018 and March 2020, and 22 patients were selected; the distribution of patients between the different scans is indicated in Figure 1.

The inclusion criteria for the performance of the studies were:

- Bioptic diagnosis of PC
- Elevated PSA
- Clinical suspicion of recurrence with detectable PSA level during or following therapy.

The ^{99m}Tc-PSMA study, a whole-body scan, and two SPECT-CT of the thorax and abdomen were performed between five and six hours post-administration of the radiopharmaceutical. The scan was performed in a

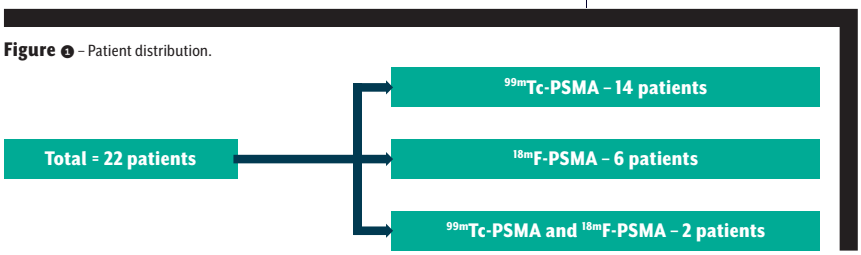
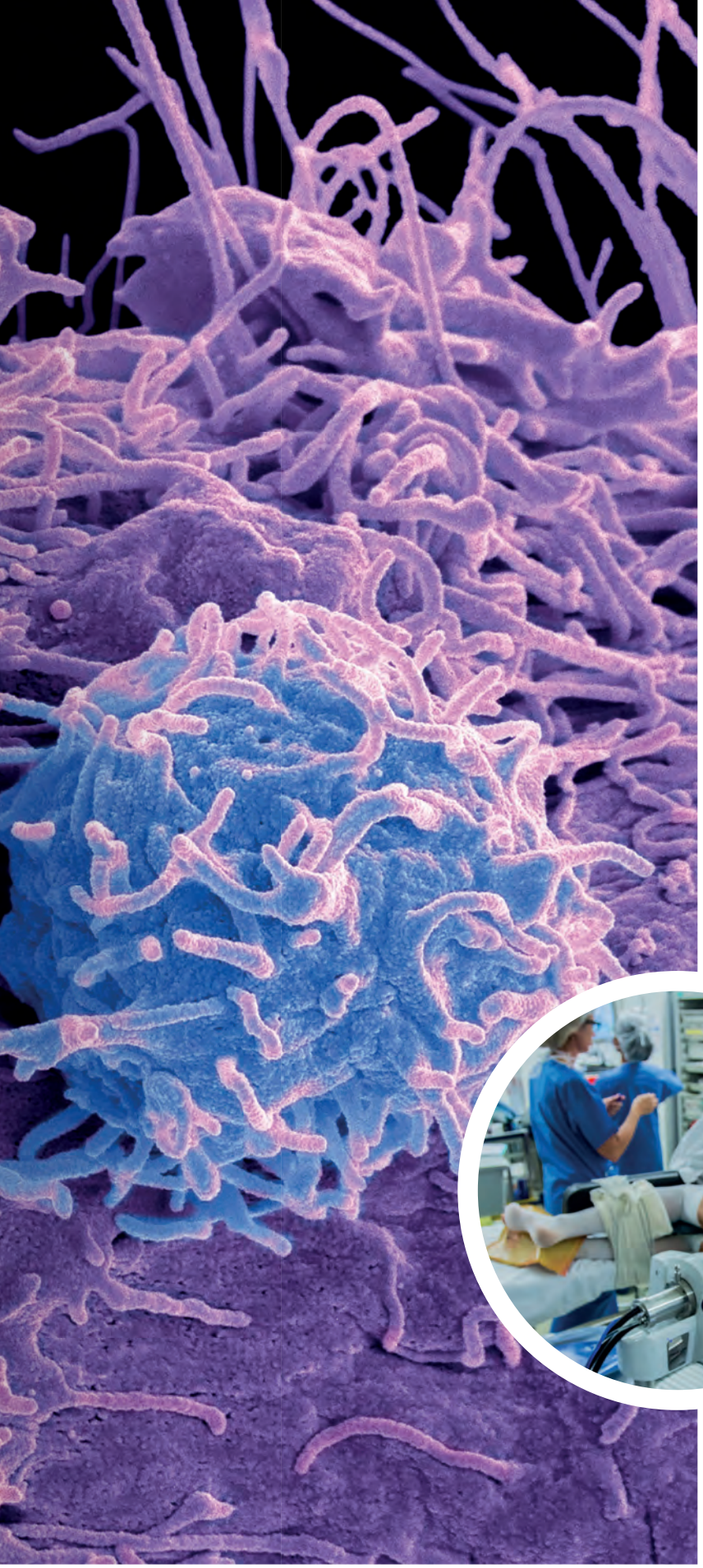


Figure 1 – Patient distribution.



PROSTATE-SPECIFIC ANTIGENS PROVIDE A PROMISING TARGET FOR PC IMAGING

gamma camera Siemens© Intevo SPECT-CT; the whole-body scan was performed at 15 cm/min and stored in a 256 x 1024 matrix; the SPECT-CT acquisition parameters can be found in Table ❶.

The reconstruction was performed with a soft tissue and bone window.

The ^{18}F-PSMA PET-CT scan was performed two hours post administration and the scan was acquired in Siemens© PET-CT Biograph 16 TP.
A venous phase was acquired in all the patients with the parameters indicated in Table ❷.

The images were reviewed by an experienced nuclear medicine physician and the abnormal uptake sites were fully described in both sets of images with special attention on prostate, local or regional lymph nodes and skeletal system.

Results and discussion

In total, 22 patient scans were analysed. Average age was 74.65 ± 7.44 years old, and the average ^{99m}Tc-PSMA and ^{18}F-PSMA administered activity was 719.94 ± 63 MBq and 453.38 ± 62 MBq, respectively. The patient demographic data is indicated in Table ❸.

Local prostatic uptake of ^{99m}Tc-PSMA was found in five of 16 patients; another five showed metastatic lymph nodes, predominantly local and iliacal, but also in the para-aortic regions. In one patient, distant metastases were also detected, namely bone metastases. In eight patients who undergone the study of ^{18}F-PSMA, local uptake was found in one patient; in six of eight patients, the study showed metastatic lymph nodes and distant bone metastases in four patients.

A total of eight patients were examined prior to the surgery – in three patients with ^{99m}Tc-PSMA positive lymph nodes, a gamma probe was used for surgical resection, which was carried out in the same day or in the morning of the following day.

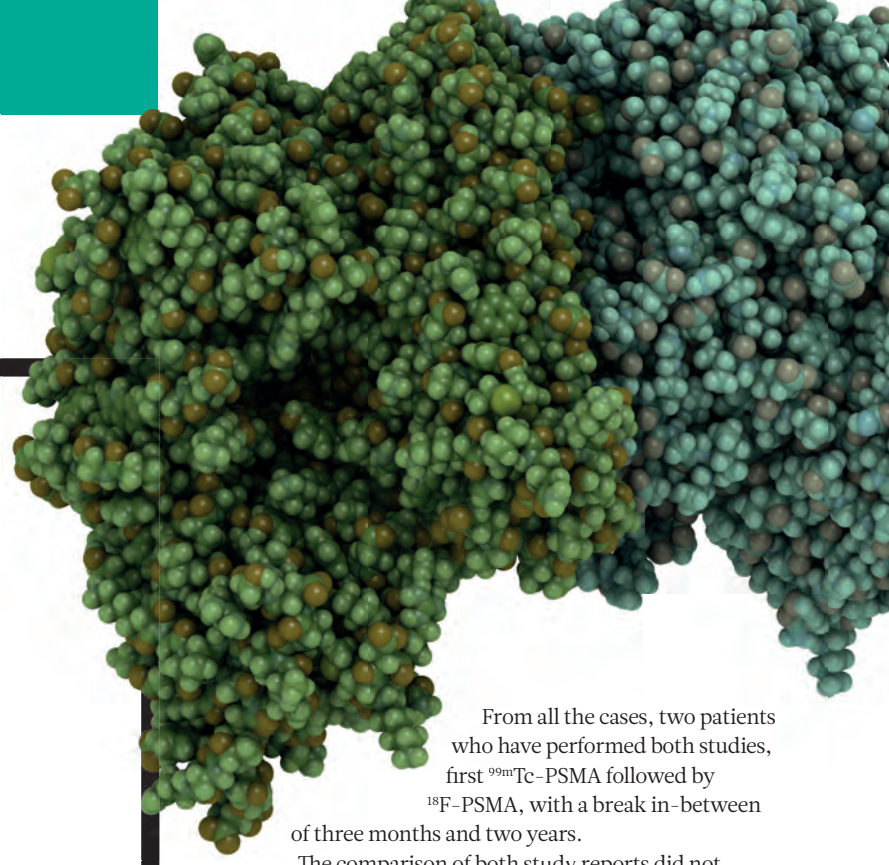


Table ❶ – The acquisition parameters used in ^{99m}Tc-PSMA SPECT-CT.

SPECT-CT Acquisition Parameters	
SPECT Parameters	**CT Parameters**
Step-and-shoot Protocol	80 mAs
180º rotation angle per detector	130 kV
32 views per detector	Slice thickness of 3.0 mm
25 seconds per view	
Matrix of 128 x 128	
LEHR Collimator	
Energetic window of 140 keV ± 20%	

Table ❷ – The acquisition parameters used in ^{18}F-PSMA PET-CT.

PET-CT Acquisition Parameters	
PET Parameters	**CT Topogram**
5 – 6 acquisition beds	25 mAs
Midß-femora to external auditory meatus	130 kV
3 minutes per bed position	Slice thickness of 0.6 mm
Matrix of 168	11 sec of scan time
FMHW of 5.0	**CT Parameters**
Caudo-cranial orientation – bladder activity increases during the scan	70 sec after contrast agent administration
	120 mAs
	130 kV
	Slice thickness of 5.0 mm

Table ❸ – Demographic data of the 22 patients included in the study.

Patient demographic data	
Parameters (units)	**Value (mean ± SD)**
Age (years)	74.65 ± 7.44
^{99m}Tc-PSMA administered activity (MBq)	719.94 ± 63
^{18}F-PSMA administered activity (MBq)	453.38 ± 62
Weight (kg)	85.04 ± 13.06
Height (cm)	178.88 ± 8.35

From all the cases, two patients who have performed both studies, first ^{99m}Tc-PSMA followed by ^{18}F-PSMA, with a break in-between of three months and two years.

The comparison of both study reports did not show any significant changes between them given that the radiopharmaceutical uptake was abnormal in both studies.

In Figure ❷ and Figure ❸, it is possible to verify two examples of ^{99m}Tc-PSMA collected during this project.

There are currently three radioisotopes available to label PSMA for diagnostic purposes – ^{68}Ga, ^{18}F and ^{99m}Tc – each of which has pros and cons. The radioisotope ^{68}Ga is normally the choice for labelling with PSMA due to a few specific properties, which includes the availability in generator form, and long physical half-life of the parent-radionuclide, which enables year-long availability of the generator. However, the emission of higher energy photons by ^{68}Ga results in higher radiation exposure to the patient as well as the operator. Correspondingly, it also affects the image quality by dropping the spatial resolution.

The radioisotope ^{18}F is another choice of labelling PSMA for PC scanning. It is produced in a cyclotron, which enables enough activity and makes it possible to produce multiple doses in a single batch, allowing commercial supply to nearby centres. The half-life of ^{18}F is 109.8 minutes; it is better for diagnostic purposes and it allows delays in the imaging.

The radioisotope ^{99m}Tc labelled with PSMA is a new inclusion. ^{99m}Tc is the most common radionuclide used for diagnosis in all nuclear medicine procedures in the world. Its physical characteristics such as its six hour physical half-life, excretion method and low dosimetry make it the best option for nuclear medicine procedures, and it can be attached to a variety of chemicals allowing its diagnostic use in several systems of the human body.

On the other hand, ^{18}F has a very short physical half-life – 110 minutes – which restricts its application

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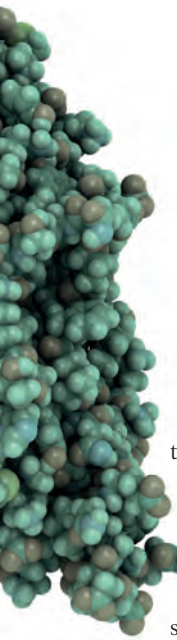


❷ Prostate-specific membrane antigen (PSMA, Glutamate carboxypeptidase II) molecule, chemical structure.

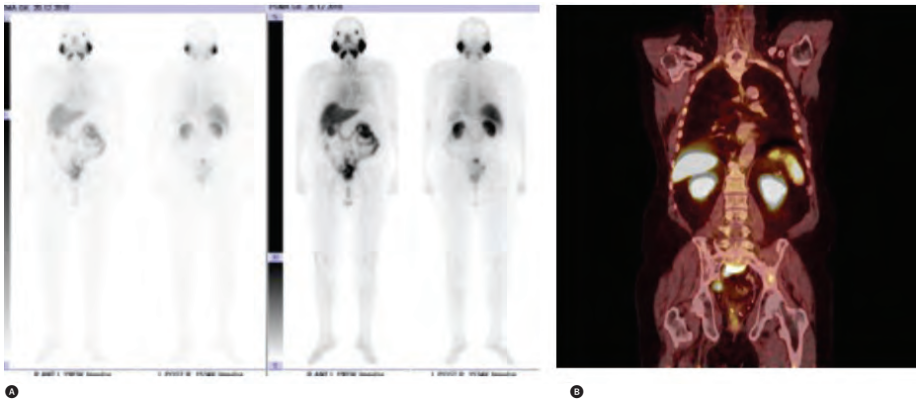
to cities nearby the cyclotron and within a six to eight hours' distance. However, ^{18}F provides a more precise and sophisticated diagnosis in PET-CT; unfortunately, this constitutes a higher radiation dose for the patient. Produced in a cyclotron, the costs associated are very high.

According to Gambhir *et al* and Singh *et al*, the ^{99m}Tc-PSMA SPECT-CT could be an acceptable and logistically simple alternative to ^{68}Ga-PSMA even in cases with low PSA levels, since there are no significant differences noted between the two modalities for staging and/or restaging. The same opinion is partially shared by Albalooshi *et al*, who confirm that ^{99m}Tc-PSMA is as accurate as ^{68}Ga-PSMA in M staging; however, the PET agent is able to detect more lesion compared with ^{99m}Tc-PSMA. Nevertheless, detection rate as not significantly different between the to techniques in patients with PSA levels › 2.1 ng/mL.

According to Heng-Chuan *et al*, PSMA SPECT/CT imaging at a range of serum PSA levels identified more metastatic lesions and provided a higher detection rate than conventional imaging modalities, helping to guide clinical diagnosis and treatment, in patients who have undergone biochemical relapse, even with low PSA levels.

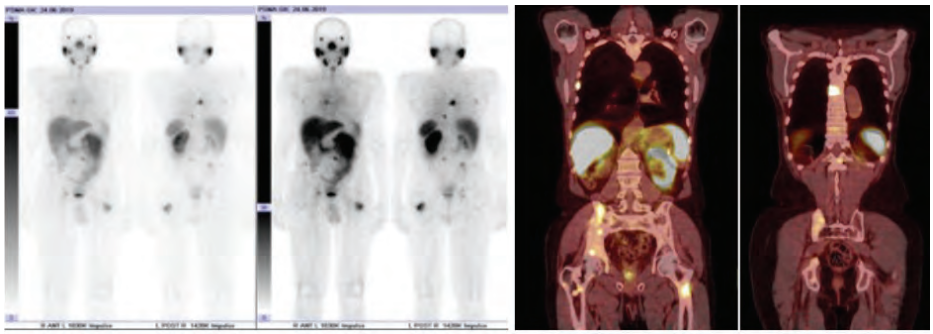
A comparison of the characteristics of ^{99m}Tc-PSMA and ^{18}F-PSMA are indicated in Table ❹.

Figure ❷ – (A) Whole-body scintigraphy with ^{99m}Tc-PSMA showing osteosclerotic lesions with expression from the radiopharmaceutical in the sacrum, pelvis and paraaortic lymph nodes. (B) Fused coronal view of 99mTc-PSMA tw years later.



Ⓐ Ⓑ

Figure ❸ – (A) Whole-body scintigraphy with ^{99m}Tc-PSMA indicating progression of the disease, specifically with PSMA expression in the pelvic region, left femur and thoracic spine. (B) Fused coronal view of ^{99m}Tc-PSMA performed three months later, showing uptake in the fifth rib, pelvic region and left femur.



Ⓐ Ⓑ

Table ❹ – Comparison of the ^{99m}Tc-PSMA and ^{18}F-PSMA characteristics.

99mTc-PSMA and 18F-PSMA characteristics		
	99mTc-PSMA	18F-PSMA
Availability	+	-
Radiation Dose	+	-
Sensitivity	-	+
Cost	+	-

Conclusion

The comparison of both studies – ^{99m}Tc-PSMA and ^{18}F-PSMA – did not show any significant changes in both studies, meaning that the uptake of both radiopharmaceuticals was abnormal. For staging and follow-up in PC, ^{68}Ga-PSMA and ^{18}F-PSMA are the tracers of first choice. Yet ^{99m}Tc-PSMA scintigraphy including SPECT-CT is an acceptable alternative with ideal physical characteristics when no PET-CT equipment or tracers for PC are available. Moreover, when applied preoperatively, it allows the specific localisation of involved metastatic lymph nodes during surgery with the use of gamma probe.

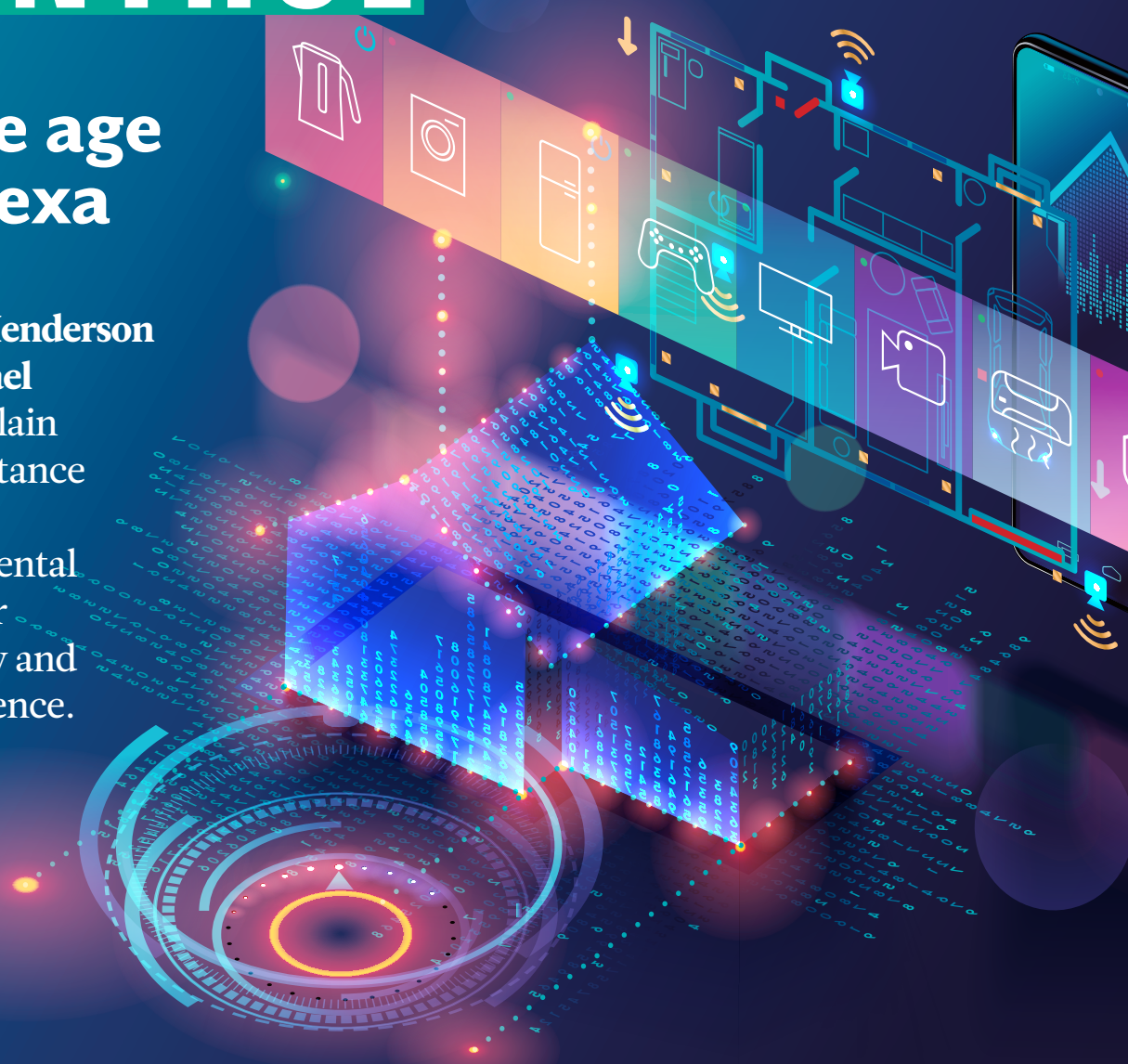
Not only does the ^{99m}Tc-PSMA have ideal physical characteristics, it also allows the specific localisation of lymph nodes and metastases before surgery with the use of gamma probes. ◘

Tania Oliveira Hackl, Bärbel Beyer, Johannes Sailer, Phillip Peloscheck, Martha Hoffmann and Clara Ferreira. *References have been supplied and can be requested from rob.dabrowski@redactive.co.uk*

CLINICAL ENVIRONMENTAL CONTROL

In the age of Alexa

Graham Henderson and **Michael Dolan** explain the importance of clinical environmental control for user safety and independence.



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Is voice and app controlled home automation an existential threat to clinical environmental control services? Or is it a welcome complementary development and enabling gateway technology? This article explores the role of a clinical environmental control service in the 'age of Alexa'. The Environmental Control Service in Edinburgh has been providing systems for over 35 years as part of an overarching Electronic Assistive Technology Service. The service cut its teeth in the 1980s developing control systems for electrically powered upper limb prostheses and interfaces for those with high-level spinal cord injuries to access microcomputers. Initially the service assessed and specified environmental control systems (ECS) for those living in Lothian and Borders health board areas, but in 1999 the service took on the installation and maintenance of ECS that it had previously subcontracted. The resulting savings have allowed many more systems to be provided, and currently there are 96 environmental control installations in Lothian. The team, consisting of clinical scientists and technologists, works closely with referring therapists and clinicians to ensure the equipment provided meets the user's needs.

Environmental control systems

ECSs enable very severely disabled people to control electrical equipment such as alarms, telephones and home entertainment equipment. Potential users who are eligible for NHS provision include those with multiple sclerosis who may not have the strength or range of motion to operate standard remotes. Despite there not being clear high-quality evidence of the positive benefits of ECSs, studies have indicated that the technology has potential to increase independence and quality of life.

The first ECSs were developed in the 1960s at the National Spinal Injuries Centre at Stoke Mandeville. They were initially designed to control a light and TV via a sip and puff switch system. From the 1990s, ECSs have taken advantage of the development of readily available low-cost electronics including integrated microcontrollers. ECSs consist of three main parts: the input device, also known as the access method (e.g. touch screen, head pointer, switch, voice activation), the controller itself, which usually contains a display, and the outputs (the devices to be controlled) (Figure ❶).

> "SMART HOME TECHNOLOGIES HAVE NOT BEEN DESIGNED WITH DISABILITIES IN MIND

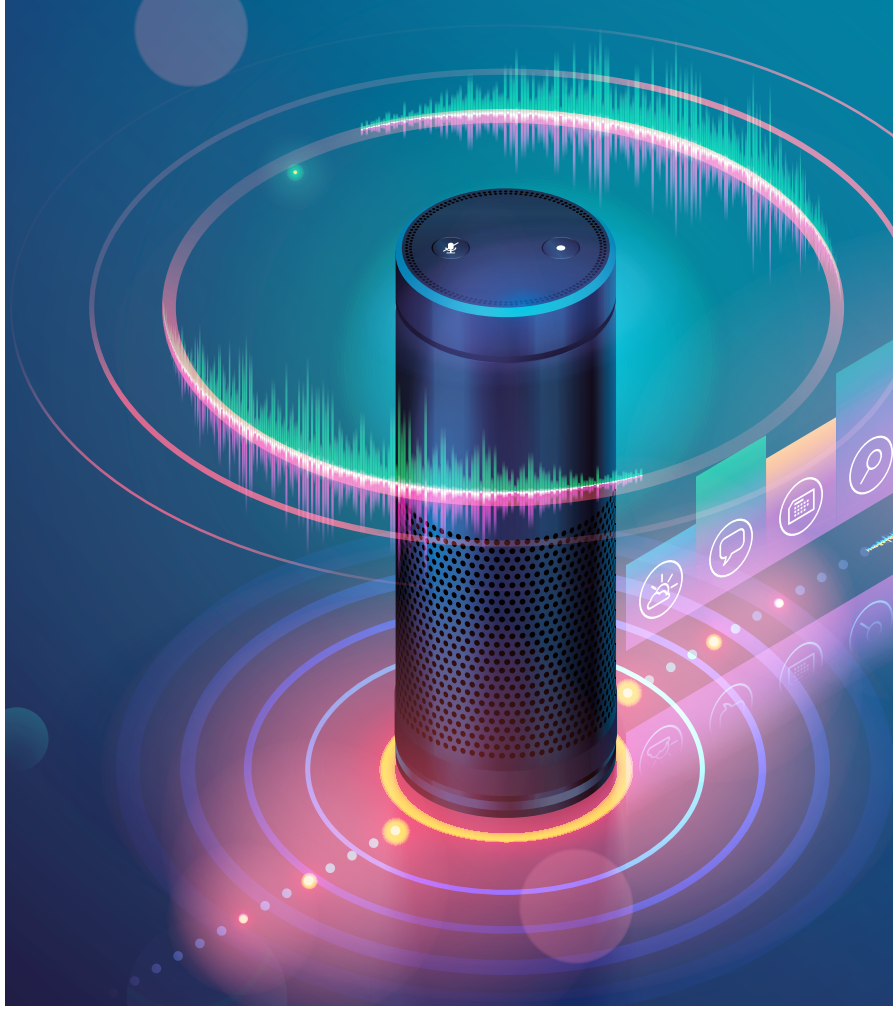
Mainstream smart home technologies

In recent years, low-cost, mainstream smart home technologies, such as voice-activated smart speakers have become widely available, e.g. Google Nest and Amazon Echo. These devices are activated by a spoken key word, the subsequent audio is recorded and sent to a server that interprets it and returns a command to the device. These devices can be linked to a wide variety of connected devices within the home. There is potential for voice-activated smart speakers to provide users with a more natural way of controlling their environment, however, there are issues concerning reliability, privacy, and security. Despite the prevalence of these devices, there is a lack of high-quality evidence to demonstrate their effectiveness in assisting people to live independently.

Mainstream smart home technologies usually consist of a hub that uses radio frequency signals (usually wi-fi) to communicate with various devices in the home (Figure ❷). A subset of these devices includes voice-activated smart speakers, which are primarily designed to be operated via the user's voice. However, they also have an associated app that could be controlled via a touch screen or a Bluetooth switch. For controlling devices such as televisions and set-top boxes, it can be done either directly via wi-fi, or sometimes an intermediate device is required that contains an infrared transmitter. Phone calls to other voice-activated smart speakers, landlines and mobiles can be made via the internet.

ECS v Smart Home Technologies

Table 1 demonstrates the different features of ECSs compared to smart home technology systems. Due to their primary audience being a mainstream one, smart home technologies have not been designed with people with disabilities in mind. For example, voice-activated smart speakers do not have an alternative access method as a back-up. If smart home technologies are not being installed by a clinical service then the onus would be on the user to install the device and this may be a barrier to some due to the technical skills required. Even if the equipment has been set up, the system will require some ongoing maintenance including updating of any apps or firmware. This could potentially be done by a clinical service but without access to round-the-clock support it is possible that insufficient knowledge of the system could lead to abandonment.



ECS AND SMART HOME TECHNOLOGIES CAN PROVIDE INCREASED AUTONOMY AND IMPROVED QUALITY OF LIFE

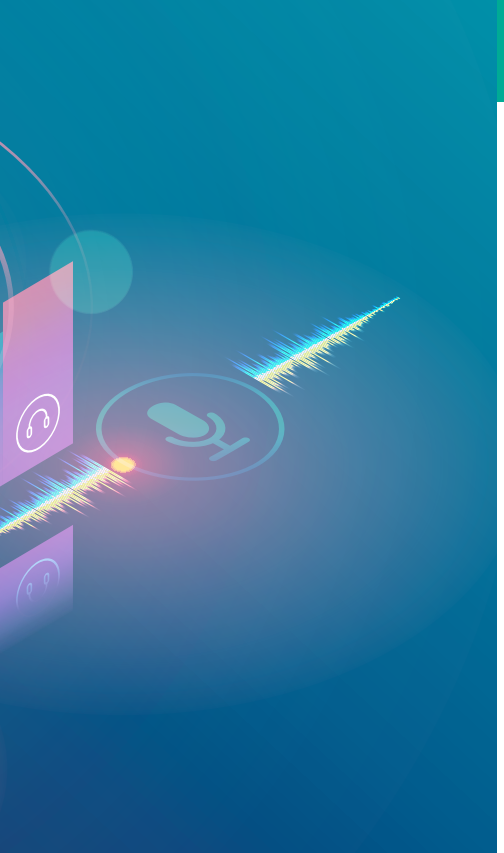
Another issue with smart home technologies is that they are not manufactured as medical devices and therefore do not need to undergo the same level of safety and reliability testing. An example of this is that they do not need to be supplied with a medical device power supply. These power supplies are manufactured to meet the relevant medical equipment safety standard and have superior features such as increased isolation between the AC input supply and DC output supply. In addition, smart home technologies do not have a battery back-up feature, which means the equipment cannot be used if there is a mains power supply failure.

To the authors' knowledge there are no commercial solutions for triggering a community alarm via smart home technologies. A community alarm is a phone-based system that enables a user to contact a call centre with the press of a button (usually via a push-button pendant). The call centre can then arrange for suitable actions to be undertaken, for example, contacting key people and/or the emergency services. The likely reason for commercial solutions not triggering community alarms is concerns over the reliability of using a wi-fi network for a safety-critical function. ECSs usually use a radio signal to communicate with community alarm systems.

Due to the reliance on a wi-fi network and a broadband connection, there is an inherent reliability issue with using voice-activated smart speakers as ECSs. There is also the issue of the reliability of the speech recognition algorithms and whether they will be able to detect the correct command, particularly for patients with speech dysarthria. For these patients, the accuracy of the voice recognition can be as low as 50–60%. This would mean that the systems are not suitable for safety-critical functions. Even for non-safety functions, this level of reliability would likely lead to frustration and, therefore, device abandonment.

Table 1 A comparison of features between ECSs and smart home technologies

Feature	Environmental control systems	Smart home technologies
Fully customisable system operation	☑	☐
Access methods are highly configurable and reliable	☑	☐
Devices can accept multiple access methods	☑	☐
Devices can be classified as medical devices	☑	☐
Battery back-up protection	☑	☐
Enable reliable triggering of a community alarm via a range of switch types	☑	☐
No internet connection required	☑	☐
Low cost	☐	☑
Compatible with a wide range of third-party peripherals	☐	☑



When it comes to cost, smart home technologies are less expensive – hubs can be bought for less than £100. Another advantage of smart home technologies is their compatibility with third-party peripherals. For example both the Amazon Echo and the Google Nest systems are compatible with a plethora of third-party devices, including light bulbs, thermostats, sockets, and security cameras.

Discussion

Studies have indicated that ECSs and smart home technologies can provide benefits such as increased autonomy and improved quality of life, though there is a paucity of high-quality evidence, including random control trials, to demonstrate their effectiveness. Further work is required to investigate the effects of ECSs and smart home technology.

One of the main barriers to uptake of ECSs is the lack of available training for users, family members and paid support staff. This could be addressed by increasing the staffing resources in ECS provision services and providing more online content. Assessments need to be completed by staff with sufficient knowledge and experience in assistive technology to ensure that provisions are fit for purpose, and to avoid the likelihood of device abandonment.

To reduce frustration and ease transition for those who lose their ability to use voice activation, flexible access methods are required and hybrid systems could be developed. These could combine convenience and ease of using voice-activated systems with the reliability and safety features of an ECS. They would need to include a community alarm function that could be non-voice activated without requirements for mains power and a wi-fi network. User-centred design methods should be employed to develop a system fit for purpose. If these issues can be addressed, then an ECS driven by voice activation could be a valuable solution for those struggling to undertake daily living tasks.

Figure ❶ A typical ECS setup

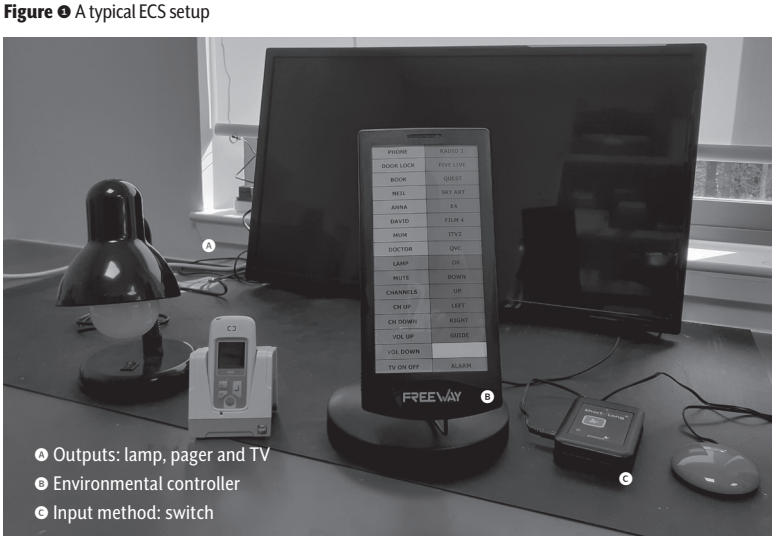
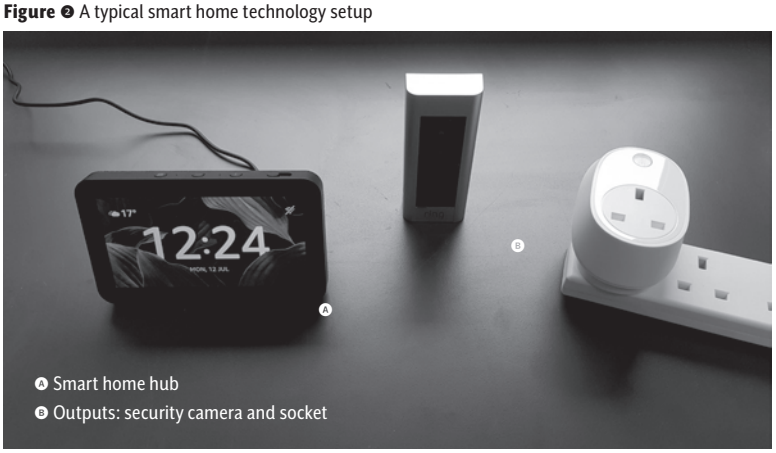


Figure ❷ A typical smart home technology setup



Conclusion

Is voice- and app-controlled home automation an existential threat to clinical environmental control services? Or is it a welcome complementary development? Unfortunately, life is too complicated to give a straightforward answer. On the one hand, if commissioners fail to understand the safety-critical advantages of ECS they may well no longer see a need to fund a clinical service, and potential users or carers themselves may not appreciate the risks associated with relying on a wi-fi based system. On the other hand, more potential users and referrers will have direct experience of the benefits of smart home technologies and will be more motivated to maintain these benefits when the former are no longer able to use commercially available devices. One could say we are beyond the dawning of the age of Alexa, and though it is not quite high noon yet, it is time to put the kettle on by fair means or foul.

Graham Henderson is Principal Clinical Scientist and Dr Michael Dolan is Head of SMART Services, both at NHS Lothian, SMART Centre, Astley Ainslie Hospital, Edinburgh

PATTERNS OF COMPUTING IN MP&CE

The results of a survey, assessing clinical and scientific computing support, raises questions regarding training and job descriptions.

The IPEM Workforce Intelligence Unit (WIU) exists to provide accurate data on medical physics and clinical engineering (MP&CE) services and staffing. Clinical and scientific computing (CSC) is a small primary MP&CE specialism but computing activities are common to all. In this article, we use CSC activities to cluster the respondents of a survey, to try to provide clear insight into the CSC contribution.

A previous Informatics and Computing Special Interest Group (ICSIC)/WIU survey, published in *Scope*, reported that 65% of the 43 responding departments had difficulty recruiting computing staff, and 73% said they had insufficient staff resources. A subsequent survey was conducted in early 2019 to look at the activities, skills, education and training of staff involved in CSC. The previous survey was 'top-down', run via heads of departments; the 2019 survey was conducted 'bottom-up', using an online questionnaire targeted at individual members, and we report its data here.

The 2019 survey attracted 125 individual responses (Figure ❶) representing 45 institutions (41 NHS and 4 private). Only 19 institutions overlapped with the 2015 survey, although 21 respondents did not declare an affiliation. One hundred and thirteen responses were kept for analysis.

Survey findings: specialisms and computing activities

Respondents were asked for their primary and secondary MP&CE specialism, and to estimate the percentage of their time spent doing specific computing activities. Radiotherapy (RT) physics was the most common primary specialism, followed by CSC, Diagnostic Radiology (DR), Non-Ionising Imaging (NII), Nuclear Medicine (NM), Clinical Engineering (CE) and Clinical Measurement (CM) with single respondents from Radiation Protection (RP) and Rehabilitation Engineering (RE).

A clustermap is a heatmap ordered using agglomerative hierarchical clustering (AHC) to help identify patterns. AHC iteratively groups individual cells together into clusters, based on their distance apart. The clusters are then merged together, using a linkage criterion to define the inter-set distance, until one remains. Dendrograms along the top and left-hand side of a clustermap show the AHC output for rows and columns, with the tree heights indicating the strength of the relationship.

Figure ❷ shows a clustermap of the percentage of time spent on CSC activities reported in the survey. On the left-hand side, we show the primary specialism of each respondent, the secondary specialism (if applicable) and the cluster groups revealed by the AHC. The figure is complex, but serves to illustrate the diversity of the workforce undertaking computing activities.

Starting at the top and working down, a large (n = 28) cluster, comprised mostly of RT physicists, spend the majority of their CSC time using clinical applications. Half of these have a secondary specialism. The next 35 are predominantly engaged in software

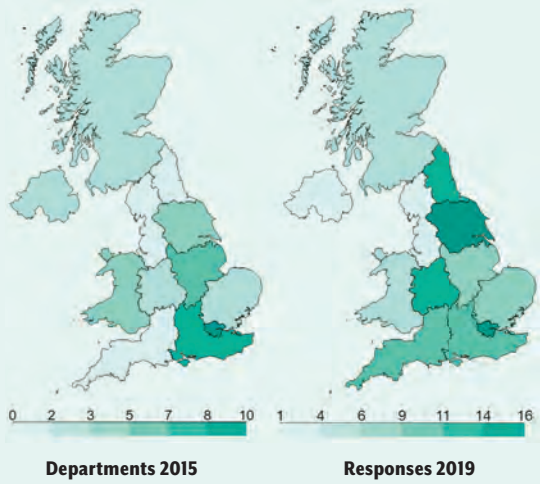


Figure ❶ Choropleths showing the regional distribution of 43 responding departments (27 institutions) from the 2015 survey and 125 voluntary individual responses from the 2019 survey

development, and are largely CSC with half the CEs; again around 50% have a dual specialism. Then comes a distinct cluster of four, predominantly using scientific applications. The remaining 46 are classified through application and infrastructure support activities and 85% declare two specialisms. This is the least homogenous cluster.

In further analysis we will combine the Clinical and Scientific Application Users in one cluster, called Application Users. This term simply references an activity and we appreciate that those using the applications will frequently also be active in supporting and developing clinical services. The first section of Table ❶ provides a breakdown of the primary and secondary MP&CE specialisms in each of the clusters. It is apparent that the activities do not fall nicely along the traditional specialism divides.

Scientific and clinical computing skills

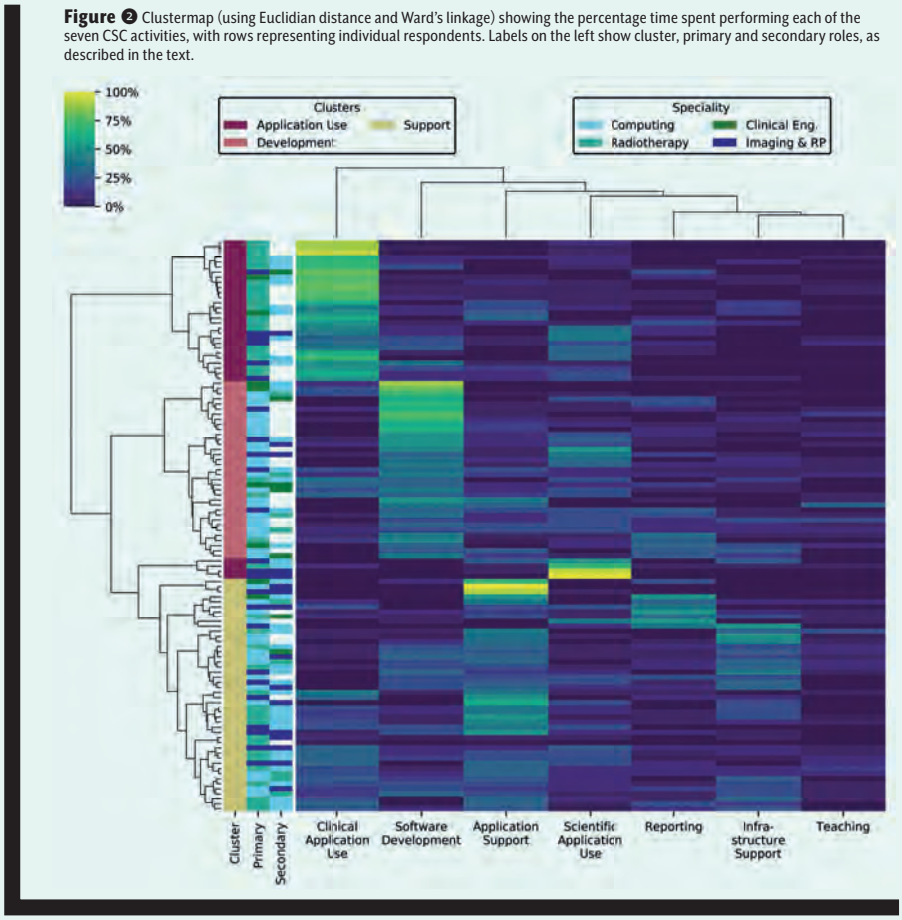
Respondents were asked to self-assess whether they had a range of CSC skills. Figure ❸ shows the percentage of respondents saying they had a skill both by primary specialism and cluster. Intuitively those frequently performing an activity should have the required skills, so deficiencies within a cluster should be more meaningful than within a specialism. Unsurprisingly then, the support group showed the widest range of skills in support activities, and developers showed the greatest proportion in database, software and web development.

The Application Users cluster was largely skilled at macro and/or script development and scientific coding, but few claimed software development skills. This indicates a common entry point to computing within MP&CE, where academic scientific coding skills are applied in the clinical environment. The result by primary specialism shows that CSC claimed more skills overall.

The skills with the fewest responders indicate areas for improvement. Bespoke hardware design had the fewest claimants, even amongst the eight CE responders. The most alarming general weakness was security review, with only 46% of Support and 16% of Application Users claiming they had the necessary skill. Cybersecurity is therefore a particular training need, especially in light of ransomware outbreaks, which appear to have risen alarmingly during the coronavirus pandemic. Good local judgements are required when cybersecurity changes conflict with medical device software upgrade policies.

Business cases and contracts/inventories management correlated with pay band, and 90% and 80% respectively of Band 8c or 8ds had these skills. System architecture skills were claimed by only 46% of Support and 43% of Developers, which indicates a training need.

Figure ❷ Clustermap (using Euclidian distance and Ward's linkage) showing the percentage time spent performing each of the seven CSC activities, with rows representing individual respondents. Labels on the left show cluster, primary and secondary roles, as described in the text.



Acquiring and developing computing skills

Skills are the product of educational background and the subsequent mix of training and self-learning. Respondents were asked for their educational background and highest qualification. Table ❶, Sections 2 and 3 provide a breakdown of educational level and background. Note that the backgrounds are dominated by physics, at 67%, and engineering, at 14%.

Respondents were asked to estimate what percentage of their computing education was through self-learning and to rate how well their education matched the tasks they performed. Figure ❹ includes results across both specialisms and clusters and first it shows that the percentage of self-learning is high. Next it shows the CSC educational satisfaction scores (0-10) by primary specialism and cluster. Respondents were largely content, so self-directed learning is not seen as a barrier. Continuing Professional Development (CPD) is a requirement of registration, and 90% of respondents were registered or working towards it so the result should perhaps not be a surprise.

The high pace of development within computing makes self-learning inevitable, and differences in technologies between centres mean that experience may not be readily transferable. It appears that recruiting a variety of MP&CE staff and allowing some to develop the necessary

CSC skills is common.

The supporting formal training pathways are problematic for CSC. The Register of Clinical Technologists (RCT) has proposed two scopes of practice, under engineering for support and under physics for development and informatics. The results of this survey indicate that this divide is artificial, but as access to computing technologist training programmes is highly desirable, this approach is welcome.

The CE Scientific Training Programme (STP) curriculum contains a CM and Information and Communications Technology (ICT) rotational module, with advanced ICT under CM and Development. The MP STP curricula contain introductory ICT within specialist modules, covering support and developmental activities. The Clinical Bioinformatics (CBI) (Physical Sciences) STP provides substantive computing training for MP&CE, but this is mixed with genomics and health informatics. Introducing genomics expertise into the MP&CE workforce should be viewed as an opportunity, but further post-registration training is often required to familiarise bioinformaticians with the MP&CE domain. These programmes do not provide the option, available in the earlier IPEM scheme, to make CSC a specialism; however, the flexible IPEM Route 2 equivalence scheme continues and provides CSC staff.

Table 1 Summary of question responses by activity cluster

		Development		Support		Application Users	
Cluster Size		35		46		32	
MP&CE Specialism							
Primary or Secondary		**1**	**2**	**1**	**2**	**1**	**2**
Radiotherapy	RT	3	4	18	5	21	0
Computing	CSC	23	7	16	21	0	12
Imaging & RP	DR	3	0	3	1	3	0
	NII	1	0	3	4	3	0
	NM	1	1	3	1	3	0
	RP	0	1	1	5	0	3
Clinical Eng.	CE	1	2	2	2	1	0
	CM	3	1	0	0	0	1
	RE	0	1	0	0	1	0
Educational Background							
Physics		19		32		25	
Engineering		8		6		2	
Computer Sci.		4		4		0	
Technologist		1		2		2	
Bioinformatics		2		2		0	
Other		1		0		3	
Educational Level							
PhD/DPhil		20		13		9	
MSc/MEng		14		28		21	
BSc/HNC/HND		1		5		2	
Professional Qualification							
SRCS		23		34		24	
RCT		1		3		3	
IPEM Associate Member		8		7		10	
MIPEM/FIPEM		14		33		18	

Continuing the development of MP&CE staff computing expertise requires departmental support. Respondents were asked whether their CSC activities were recognised in their job description (JD), and included in a formal Quality Management System (QMS). Responses are summarised Figure 4. Only half the RT respondents said that their CSC activities were within their JD. The clusters again showed that most mismatches were in the Application Users group. Furthermore, 11 of the 40 respondents who put CSC as their secondary specialism did not have the requirements within their JD.

Sixty per cent of RT respondents indicated that their computing work was within a QMS, more than any other group. Since the late 1990s it has been a requirement that multidisciplinary QMS are used within RT. Most use ISO 9001 and many have evolved to include related CSC activity. Survey responses on QMS from the support and development clusters were 50% and 54% respectively. For in-house medical device manufacture, including software, ISO 13485 is appropriate, supported by the wide range of established ISO computing standards. Whilst accreditation to BS 70000 aims to cover the full range of MP&CE activities, its benefit has yet to be proven and its philosophy may conflict with the increasingly multi-disciplinary way in which clinical computing services develop. At the time of the survey, the EU Medical Device Regulations (EU MDR 2017) were still anticipated to come into effect in May 2020, mandating a QMS for MD development. Consequent governance changes are being discussed.

> "PROFESSIONAL BEST PRACTICE IS HARD TO DEVELOP THROUGH SELF-LEARNING

It is also important that computing support activities are included within QMS. Understanding IT service provision standards such as ITIL and the ISO 20000 family, more familiar at corporate level, can assist in building relationships with IT departments. Healthcare specific standards such as ISO 80001, the newly published 81001 and BS EN 15224:2016 are slowly evolving and need to be kept under review.

Conclusions

Online surveys are prone to self-selection bias, with probability sampling required to produce generalisable results. The survey respondents do not adequately represent all specialisms within MP&CE, particularly those in CE. By clustering on CSC activities

Figure 3 Heatmaps of percentage of respondents declaring they have a skill by primary role and cluster.

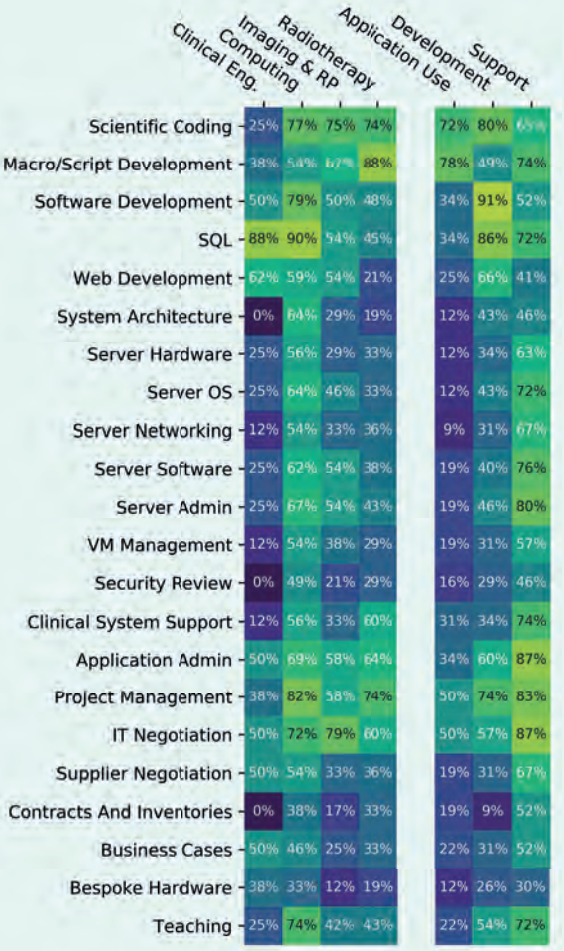
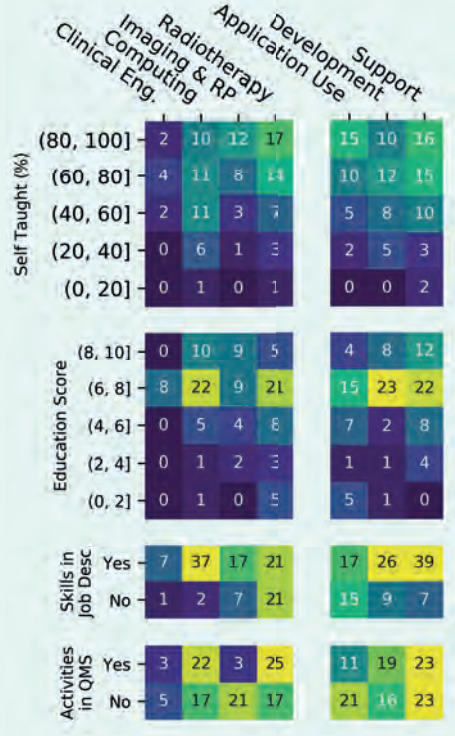


Figure 4 Heatmaps of count of responses to percentage self-taught, education sufficiency score, Skills in JD and Activities in QMS by Primary Role and Cluster.



we have highlighted distinct groups that span MP&CE specialisms, and the survey results may generalise better within these clusters. This also draws attention to the possibility that CSC JDs can be applied across departments, rather than just within sections.

The question of how best to train and plan for CSC positions remains and a skills shortage was already indicated by the 2015 survey. Our survey indicates that CSC skills are generally self-learnt rather than formally acquired. Formal CSC training is available via the CBI (Physical Sciences) STP. Although many find this term imprecise, MP&CE members have had a large input into its curriculum, ensuring that it covers the full range of required CSC activities. However, it does not cover any other individual MP&CE specialisms in depth as the earlier IPEM scheme did, so some further training will be needed in post.

IPEM's NHS members have Electronic Staff Records (ESRs), derived from their JD. The NHS ESR System, overseen by NHS Digital, is frequently updated, and CBI job codes have been introduced since the WIU last issued guidance. These can be used with MP&CE areas of work, to reflect the need for CBI STP training posts. The survey reveals that 29% of respondents had CSC as their primary specialism and 33% as a secondary one. Furthermore 27% performed CSC activities outside their JD, an unsatisfactory situation. The ESR system allows for accurate job splits so a staff member can be recorded twice using CBI and MP/CE codes with appropriate WTE. How about suggesting that at least two JDs in most small departments and some suitable percentaged in larger ones have CBI as the primary specialism?

To support CSC and WIU, heads of department should begin to consider how to use CBI in JDs,

Considering the further development of CSC skills in-post, technical information is readily available online and commonly used, but professional best practice is generally harder to develop through self-directed learning. CPD courses provided by IPEM can help. ICSIG ran well-subscribed workshops in 2017 on DICOM and 2018 on software development. A course on support activities was under development when ICSIG was disbanded.

Departmental managers can help by encouraging staff interested in CSC activities to collaborate in service provision and support, importantly considering cross specialism collaboration. Locally posts naturally develop and this can lead to the creation of formal computing groups, so, as specialisms grow, it is important to keep JDs aligned with activities.

Finally, we would like to thank the 125 respondents to the survey, and apologise for the delay in reporting results. The WIU really needs support from the membership when it requests information.

*Prepared by **Adam Chalkley**, a Clinical Scientist at the University Hospitals Birmingham NHS Foundation Trust, **Edwin Claridge**, a retired Clinical Scientist, **Jemimah Eve**, Head of Workforce Intelligence and Training at IPEM and **Adam Hyett**, the IPEM Workforce Intelligence Unit Administrator.*
We would like to acknowledge discussions with Dan Warren, who suggested the use of clustermaps. ***An extended version of this article will be published on the IPEM WIU pages, with references.***

An appeal for IPEM members to help in supporting and improving the physics education of future radiologists.

EDUCATION OF FUTURE RADIOLOGISTS

The Royal College of Radiologists (RCR) is responsible for setting the curriculum that clinical radiology trainees must follow in order to gain fellowship of the college (FRCR), which is a requirement to become a consultant radiologist in the UK. The RCR also administers the various examinations associated with this curriculum. These include the FRCR part 1 scientific basis of imaging examination, often known as the part 1 physics exam. This is typically taken by radiology trainees in their first year of speciality training and a pass is required to progress further in the training scheme.

The RCR has a Clinical Radiology Physics Exam Committee (PEC) made up of seven radiologists and five physicists. In practice, this means for each of the different imaging modalities covered in the curriculum there is only a single physicist on the committee specialising in that field. Each member of the committee has a five-year term of membership, so there is a steady requirement for new members.

The PEC is responsible for ensuring, on behalf of the Fellowship Examining Board, that the physics component of the first FRCR examination provides an appropriate assessment of the knowledge of the physical principles that underpin diagnostic medical imaging as defined in the physics syllabus section of the curriculum. The PEC selects questions for the physics exam from a question bank, standard sets the questions to produce a pass mark, and develops new exam questions for the bank. There are also opportunities to shape the physics syllabus within the curriculum itself and to link in with other RCR activities, particularly regarding education. The RCR is not responsible for the provision of the training, which is covered by Health Education England and is organised and delivered separately in different geographical regions across the UK.

The PEC meets four times a year at the RCR in London when face-to-face meetings are possible. One of these meetings focuses on strategic discussions, allowing time for reflections beyond the routine exam management. The other meetings are devoted to creating and reviewing the exams for the three exam sittings per year. These meetings may include the following:

1. Review the results of the most recent exam and the performance of each question. Where appropriate, poorly performing questions are modified or removed from the questions bank
2. Proof read the final draft of the next exam, double checking for spellings, accuracy, duplication of questions, possible ambiguity, etc
3. Standard-set the exam questions for two exams ahead. Standard setting of exams is performed via Angoff scoring, where the expected percentage of just-passing candidates correctly answering each question is estimated by each member of the PEC and an average taken across the group
4. Select questions for three exams ahead. An initial selection of 80 sets of questions from the question bank by one of the radiologists is reviewed by the PEC and half of these questions are selected for the exam. Where appropriate, the wording of questions is updated.

The FRCR physics exam

Currently, the exam consists of 40 sets of five multiple true/false questions on a particular topic in the physics syllabus, with each set of questions having a common stem. This provides 200 questions.

IMAGES: SHUTTERSTOCK

> THE RCR WOULD LIKE TO ENCOURAGE IPEM MEMBERS TO CONTRIBUTE TO THE GENERATION OF PHYSICS EXAM QUESTIONS

A small list of sample questions produced by the FRCR part 1 exam committee is on the RCR website (**bit.ly/3C18jCM**) from which one example is reproduced below:

Radionuclides

a. are those nuclides having more neutrons than protons
b. may emit x-rays
c. decay exponentially
d. do not occur naturally
e. may be produced in a cyclotron

However, there is currently a plan to move towards more single best answer (SBA) questions, as requested by the General Medical Council. Typically, an SBA question might be a clinical scenario followed by a number of options, one of which is considered to be the best. It is believed that SBA questions better test the application of knowledge and are fairer to candidates. They also provide the benefit of being able to include images within the question. However, it is recognised that SBAs are more difficult to formulate in the context of imaging physics than perhaps other areas of medical practice. Additionally, SBA questions take longer to answer and so fewer questions can be posed in each exam, potentially limiting assessment of the candidates' knowledge and negatively impacting on exam statistics. It is likely that future exams may be a mix of true/false and SBA approaches. See ❶ for an example of an SBA question.

❶ An example of an SBA question

Appropriate window parameters for viewing the lung parenchyma in the image would be:

	Window level (WL)	Window width (WW)
A	40	80
B	400	1800
C	50	400
D	50	350
E	-600	1500

What the FRCR physics exam committee needs from you

1) Suggestions for physics exam questions

As part of an agreement (**bit.ly/3lX3ZPx**) between the RCR and IPEM, the PEC has already reached out to IPEM special interest groups to provide suggestions on relevant physics exam questions for the First FRCR examination. We would like to progress this further, and encourage all IPEM members to submit suggestions on suitable exam questions, particularly those that they feel are clinically relevant for a practising radiologist. The bank of SBA questions is very limited indeed and must be increased significantly before being able to launch fully. Details on how individuals can submit suggestions via IPEM will be clarified via the medical physics-engineering mailbase and IPEM communities of interest.

The PEC cannot provide information about questions added to the bank. However, they can give general feedback to IPEM on the contributions received.

2) Joining the physics exam committee

The PEC would like to encourage IPEM members to consider applying to join the PEC. Typically, a vacancy for another physicist to join the PEC is advertised each autumn, with the successful candidate officially taking up their role the following January. There is no financial incentive to join the PEC, although the RCR provide an efficient system to reimburse expenses for travel and any accommodation. However, PEC members are rewarded with limited honorary membership of RCR and more importantly, as part of the PEC you will be contributing directly to the future development of radiologists and clinical radiology.

Geoff Charles-Edwards**, **John Courtney**, **Richard Fernandez**, **Jonathan Hopkins**, **Prashant Verma**, **Michael Watt**, on behalf of the FRCR part 1 physics exam committee. For more information, email **geoff.charles-edwards@gstt.nhs.uk

ONLINE DOSIMETRY CONFERENCE

Clive Baldock reports on IC3DDose 2021 – the 11th International Conference on 3D and Advanced Dosimetry.

The DosGel conference has been running since 1999, and an original aim of the first conference was to bring together both researchers and end users with an interest in the application of 3D radiation dosimetry techniques in the treatment of cancer. A mix of presentations, from basic science through to clinical applications, always remained an objective for all subsequent conferences, with participation encouraged particularly from graduate research students and early career researchers for in-depth discussions and knowledge sharing with more senior researchers and clinical practitioners.

Evolution

Over the years, as the rapidly increasing demand for advanced high-precision 3D radiotherapy technology and techniques continued, the need for practical and accurate 3D dosimetry methods for development and quality assurance only increased.

By the sixth meeting, held in Hilton Head, South Carolina, in 2010, the conference scientific committee recognised wider developments in 3D systems and advanced dosimetry techniques and decided to widen the scope of the conference by a change of name from DosGel to IC3DDose. Subsequent IC3DDose conferences were held in Sydney, Australia (2012), Ystad, Sweden (2014), Galveston, Texas (2016), and Kushan, China, (2018), with the most recently conference (2021) held virtually.

Since 2004 the DosGel and IC3DDose conference proceedings have been published in the Institute of Physics' *Journal of Physics: Conference Series*, which over the years has included over 125 invited papers and nearly 600 proffered papers.

The 11th IC3DDose Conference had originally been scheduled to be held in Quebec City in Canada in 2020. However, due to COVID-19 restrictions the meeting was successfully moved by the local organising committee of Luc Beaulieu, Louis Archambault (Université Laval, Quebec City) and L John Schreiner (Queen's University, Kingston) onto a virtual conference platform

IMAGES: SCIENCEPHOTOLIBRARY

"ACCURATE, PRACTICAL DOSIMETRY NEEDS HAVE INCREASED

and scheduled to accommodate participants across 17 time zones.

Virtual conference

Three of the virtual conference days from 10 to 13 May accommodated a 90-minute scientific session of oral presentations using Zoom, with a virtual poster session held on the last day. The traditional face-to-face conference format, with relaxed personal interactions over poster viewings and in vendor exhibition booths, was moved to the interactive SpatialChat virtual platform. Virtual poster rooms enabled participants to gather around posters for free discussion with the presenters. The SpatialChat software enabled participants to only hear the discussion in their immediate position in the virtual space.

Commercial vendors each had two rooms in the SpatialChat virtual conference, one for a virtual booth and one to show videos highlighting their products and services. Conference attendees were able to visit the vendor spaces and talk with these industry partners much as they would be able in an exhibit hall during a live meeting.

One of the oral sessions was dedicated to young investigators through a Rising Star Competition, with first prize awarded to Marie-Anne Lebel-Cormier from Université Laval in Canada for "On the feasibility of using an optical fibre Bragg grating array for multi-point dose measurements in radiation therapy".

All participants of IC3DDose 2021 commended the organising committee of the original in-person IC3DDose conference for very successfully moving the meeting onto a virtual platform.

The next conference, 12th IC3DDose is planned to be held face-to-face and in-person in Quebec City in June 2022.

Clive Baldock *is Dean of Graduate Research at the University of Wollongong in New South Wales, Australia.*

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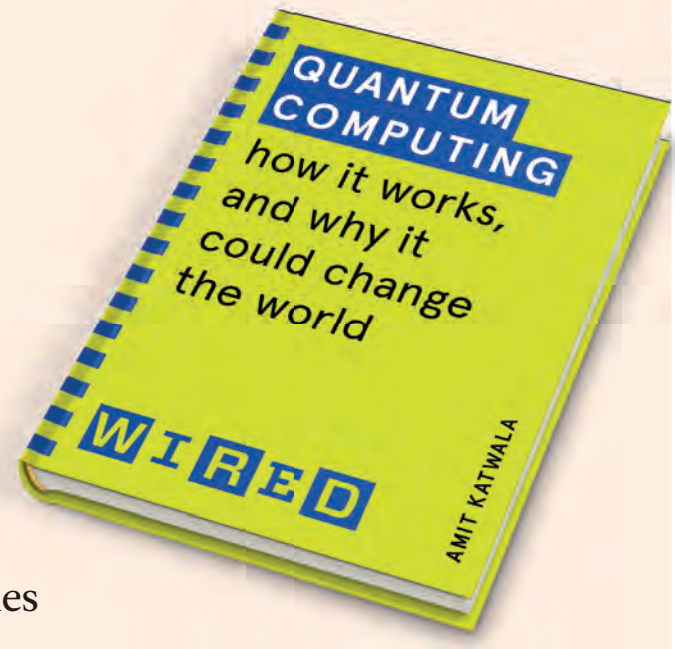
BOOK PITCH

Quantum computing



Science and technology writer **Amit Katwala** outlines the ideas behind and the content within his new book.

Quantum computers can be difficult to get your head around. They're not simply a faster type of computer – instead, they turn the uncertainty of quantum physics to their advantage to tackle certain types of complex problems exponentially quicker than even the very best supercomputers.

Instead of using bits, which can either represent 1 or 0, quantum computers use qubits, which can be 1, 0 or a state somewhere in between known as a superposition. That means they're better at handling uncertainty than traditional computers, and can be much more efficient at simulating nature.

That gives quantum computers potential for solving problems in medicine. How will a new drug interact with the body? What will a change to a single amino acid in a complex protein do to its structure? What's the most efficient way to allocate scarce resources? These are all problems that could be effectively tackled by a quantum computer.

They could, for instance, speed up the discovery of new drugs by enabling pharmaceutical researchers to quickly identify new compounds, and then simulate their effects without having to synthesise them. Quantum computing could also help scientists model complex interactions and processes in the body, enabling the discovery of new treatments for diseases such as Alzheimer's, or a quicker understanding of new diseases such as COVID-19. Companies such as DeepMind are using artificial intelligence to gain insight into protein folding – a key facet of growth and disease – and quantum computers will accelerate this effort.

They could also help with the treatment of rare disease. Quantum computing offers the possibility of creating data where none actually exists in the real world, through a process known as generative modelling. It's already being done on classical computers, but quantum devices could do it faster and at a larger scale.

The additional power of quantum computers could be used to extrapolate from limited data sets, and feed machine-learning algorithms with data, even when we don't have it. "Enhancing this allows us to do things with scant data – whether that's looking for rare lung cancer in MRIs, or in facial recognition, where you have a lot of pictures of the side of a face but not the front of a face," says Christopher Savoie of Zapata Computing. It is, he says, like creating deep fakes that are as good as the real thing.

"QUANTUM COMPUTERS COULD HELP TREAT RARE DISEASE

You'll notice I've used the word 'could' a lot in the words above – and that's because these claims do have to be taken with a pinch of salt. We're still very much in the early days of the field – the equivalent of room-sized computers made from vacuum tubes in the 1960s. Quantum computers are incredibly difficult to build and scale up, and it will be years or even decades before some of these applications become a reality.

But companies including Google, Amazon, IBM and Tencent are racing to build practical quantum computing devices. In 2019, Google claimed to have reached quantum supremacy – the first time a quantum device had outperformed the world's best classical supercomputer. Researchers are already writing algorithms and using what they've learned to squeeze more out of classical computers, and billions in funding is pouring into the field. Quantum computers could have a huge impact on cybersecurity, finance, energy and healthcare. But for now, their future remains uncertain.

Imaging 1st

Imaging First Ltd, first opened in 2012 providing new and used ultrasound systems, probes, probe repairs and servicing options, we have continued to grow the business and are now on the NHSSC Framework for both equipment sales and servicing, with both new and used systems and probes in stock from a range of manufacturers.

Imaging First and Edan Medical

In 2019, we became the official UK distributors for Edan Medical ultrasound systems.

The Acclarix range starting with the AX3, with dual probe port and dual battery functionality, customisable touch screen interface in a 4.5kg lightweight body, produces great performance in a portable system, alongside its more powerful sibling, the AX8 with the addition of a tilt and swivel monitor and high clarity image quality, Edan have produced two portable systems that provide exceptional quality.

The new LX9 cart-based system, goes a step further in simplifying the experience for the user, it makes day-to-day operation an easy, fast and intuitive experience. With five probe ports, a customisable touch screen user panel and is available with additional options such as eLV, eOB, eVol.Flow and eFollical providing additional automated tools for stronger capabilities.

Imaging First and iCAD

In July this year, Imaging First became the official UK distributors for iCAD of their ProFound AI range of artificial intelligence for early breast cancer detection and diagnosis here in the UK. ProFound AI offers a solution that empowers radiologists to find breast cancer earlier and includes solutions for 2D mammography and tomosynthesis, ProFound AI also offers multi-vendor compatibility.

With two new options, ProFound AI Risk: The only clinical decision support tool that provides an accurate two-year breast cancer risk estimation that is personalised for each woman, based only on a screening mammogram and the age of the patient, and PowerLook Density Assessment: An automated solution to standardise the assessment of breast density to identify patients at higher risk of developing breast cancer.

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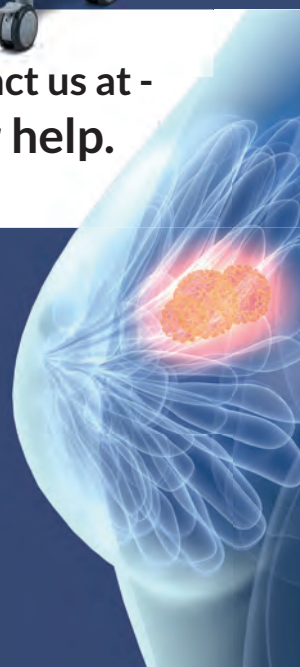

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