IPEM
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STEF
SCIENCE, TECHNOLOGY & ENGINEERING FORUM

Book of Abstracts

Central Hall Westminster, London

Wednesday 9th - Thursday 10th October 2024

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SCIENCE, TECHNOLOGY & ENGINEERING FORUM

IPEM Science, Technology and Engineering Forum (STEF)

'Beyond Boundaries: Collaborating for Tomorrow's Innovative Solutions'

9th-10 October 2024

Central Hall Westminster

The theme for the second IPEM Science Technology and Engineering Forum two-day conference will be "Beyond Boundaries: collaborating for tomorrow's innovative solutions" is designed to foster cross-disciplinary discussion and identify solutions to the challenges facing our community. This will provide a cross-disciplinary view to enable the Medical Physics and Clinical Engineering community to work together to identify solutions, so that we can tackle these challenges together.

About IPEM

Physicists, engineers and technologists play vital roles in delivering our healthcare. The Institute of Physics and Engineering in Medicine (IPEM) is the professional organisation that represents this diverse workforce. We are a charity with more than 4,600 members drawn from healthcare, academia and industry. Our mission is to improve health through physics and engineering in medicine. Our members help to ensure that patients are correctly diagnosed and safely treated for illnesses such as cancer and stroke. They also maintain and manage vital medical equipment such as MRI and ultrasound scanners, X-ray machines, drug delivery systems and patient monitors. Their research and innovation leads to new technologies and methods that improve on existing medical treatments. They provide new solutions that enable older people and patients with injuries or long-term conditions to complete everyday tasks.

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Contents

Poster

An evaluation of open-source artificial intelligence auto-segmentation software for radiotherapy treatment planning of lung cancer

Virginia Marin Anaya, Abodunde Samuel Adegunloye, Daniel Sandys, David Ramlakhan

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Abstract

Background: Microsoft InnerEye deep-learning is an open-source toolkit [1] for training and running inference on segmentation models. This study uses a trained machine learning auto-contouring model for lung cancer. We share our initial experience of using the trusted research environment (TRE) and assess both accuracy of generated auto-contours and the integration of the lung model into existing workflows at our organisation.

Methods: Collaboration with Microsoft Research Cambridge allowed us to overcome initial technical challenges in accordance with the NHS Long Term Plan. Geometric analysis of the auto-contours was performed using various evaluation metrics such as the Dice Similarity Coefficient (DSC) and the Mean Distance (MD). Twenty stereotactic ablative radiotherapy lung cancer patients were selected retrospectively. The lung segmentation model was run on the data within the TRE. Retrospective manual contours for these patients were used as reference.

Patient and public involvement [2] was embedded in the study to understand more about the

perception of cancer patients towards AI.

Results: For lung left, lung right, spinal cord, oesophagus and heart, median DSC values and range between brackets were 0.972 (0.884, 0.984); 0.973 (0.725, 0.983); 0.815 (0.509, 0.900); 0.602 (0.276, 0.739) and 0.462 (0.214, 0.814), respectively.

Table1.

Structure - Left Lung

DSC - 0.97 (0.88, 0.98)

MD (mm)) - 0.82 (0.39, 4.2)

Structure - Right Lung

DSC - 0.97 (0.73, 0.98)

MD (mm)) - 0.90 (0.57, 6.5)

Structure - Spinal Cord

DSC - 0.82 (0.51, 0.90)

MD (mm)) - 2.8 (1.2, 5.8)

Structure - Oesophagus

DSC - 0.60 (0.28, 0.74)

MD (mm)) - 1.2 (0.58, 23.1)

Structure - Heart

DSC - 0.46 (0.21, 0.81)

MD (mm)) - 14.3 (7.3, 23.6)

Table1. Geometric analysis. Results are expressed as median and range between brackets.

Discussion: The lung model showed disagreement between retrospective manual contours and auto-contours for the heart and oesophagus. This could be caused by shortcomings in the training dataset used [3]. Auto-contours must be used as a starting point, reviewed, and edited, if necessary, by the clinical oncologist.

Conclusion: Our experience with the machine learning model provides evidence of the applicability of this auto-contouring solution in radiotherapy after overcoming the practical challenges related to the TRE. This project could have immense potential to improve patient outcomes and increase productivity in radiotherapy in the wider NHS.

Key references:

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train and deploy 3D segmentation models on Azure Machine Learning,

https://github.com/microsoft/InnerEye-DeepLearning (accessed March 2024)

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SCOPE Summer 2023. Vol. 33, issue 2, pp.22-27

3. Lung Segmentation Model - InnerEye-DeepLearning 0.7 documentation,

https://innereye-deeplearning.readthedocs.io/md/lung_model.html (accessed March 2024)

Ethics approval: HRA Approval has been given (IRAS Project ID: 306032) for UCLH evaluation of InnerEye cancer models for radiotherapy planning using UCLH dataset.

3

The use of deep-learning convolutional neural networks (CNN) for auto-classification of digital histology slides of uveal melanoma

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Abstract

Background: The use of deep learning (DL) and artificial intelligence (AI) in cancer medicine has rapidly grown in recent years with the improvement of Graphics Processing Units, increased availability to computing power and improvement in digital imaging and storage. The aim of this study is to apply various DL models to automatically detect certain features in uveal melanoma (UM) histology slides called vascular lakes (VL) which were found to correlate with bad prognosis.

Methods: The dataset consists of a total of 136 slides. Patches have a mixture of three categories, background, which contained sections of the eye but no tumour cells, tumour cells only, or tumour which contain VL. Patches without tumour tissue were included for the balance of the different categories and robustness of the model. Three AI models were investigated using Matlab 2020a and Python; DeeplabV3+, U-Net and Fully Convolutional Network (FCN). Performance of these models was assessed in terms of accuracy and the Jaccard Similarity Coefficient (JSC).

Results: DeepLabV3+ obtained the highest accuracy and JSC score with network-depth being highly relevant to performance. No significant differences were found in performance between different DeepLabV3+ architectures regardless of depth. However, there were significant differences in the performance between the DeepLabV3+ ResNet50 and the U-Net segmentation performance (Kruskal-Wallis, $p<0.05$). Significance values were adjusted by Bonferroni correction for multiple tests.

Discussion: This study analysed three AI DL models on sections of slides with UM: FCN, DeepLabV3+ and U-Net. The evaluation of these models showed that the DeepLabV3+ performed better than other CNN architectures, regardless of the depth of the network used. However, all networks JSC improved as the depth increased; this could be due to deeper networks being able to extract more subtle features than smaller networks which tend to extract more global features. However, none of the performances were statistically different, and all three ResNet models achieved accuracy >0.9 and JSC >0.65. Therefore, the time taken to run the CNNs should be considered when choosing which CNN architecture to use, as architectures with greater depth generally take much longer to run. Meanwhile, the FCN-ResNet had lower JSC performances than DeepLabV3+, and the U-Net performed worst overall.

Conclusion: This is the first study to evaluate whether VL could be segmented from histology slides of UM showing very promising results. This study could now be modified to include other clinical data making it a more clinically useful. It may also be of value to evaluate other pretrained CNN architecture,

such as VGG-16, AlexNet, MobileNet-V2 and Xception, to determine if they produce significantly different results.

References:

Ching, T., et al., Opportunities and obstacles for deep learning in biology and medicine. J R Soc Interface, 2018. 15(141).

4

Smart belt design for monitoring falls, posture and basic physiological parameters in the community

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Abstract

Background

Aging population is a major concern for healthcare providers. There is a growing need to monitor people's health in the community to relieve pressure on acute service providers. The use of wearable devices in the community has gained significant attention in recent years due to rapid advances in technology. Research in the area shows that such devices can offer significant improvement to the general health and quality of life in elderly people. The adoption and uptake of this technology however remains relatively low due to the way people interact with the technology. The aim of this project is to design a practical, simple-to-use device that can be easily integrated into everyday life.

Method

The prototype incorporated the use of an accelerometer, gyroscope and digital motion processor on a single chip, the size of a 10-pence coin. The device communicates via fast I2C protocol with minimal hardware requirements. An Arduino Nano Every microcontroller was used in this prototype with a 20MHz clock and a 48KB on-board flash memory. The Arduino unit communicates to nearby devices such as laptops or mobile phones via a Bluetooth plugin module. A graphical user interface (GUI) was developed in C# using the Unity Game Engine Integrated Development Environment (IDE). The prototype also incorporated a respiratory rate monitor using a conductive rubber stretch sensor, and a heart rate monitor using an integrated signal conditioning chip. The whole device was powered using a 9V battery and the cost of the components was less than £50. In order to test the performance of the device, simulation experiments were carried out using a test object and a human volunteer. Various digital filters were used to remove noise and correct for drift.

Results

The linear quadratic estimation (LQE) filter performed best in removing noise and providing long-term stability for the posture/fall detector sensor. Simulation results showed that the sensor was successful in detecting falls as shown in fig. (1) below. Respiratory and heart rate monitors also performed reliably with basic signal processing techniques.

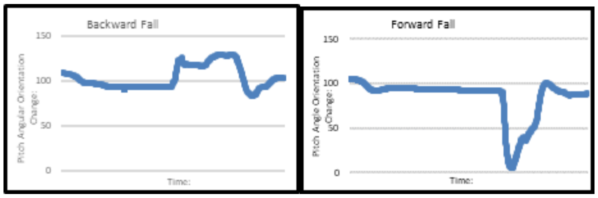

Fig. (1) Forward and backward simulated falls successfully detected by the motion censor

Discussion and Conclusions

Current state-of-the-art in microchip sensor technology and digital signal processing makes the development and utilisation of wearable devices solutions cheap and reliable. Future work is needed on data security and protection, data storage, power conservation and sustainability.

Keywords: Wearable devices, fall detection, posture, home monitoring

5

Development of a Level 4 Apprenticeship in Medical Physics

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Abstract

Development of a Level 4 Apprenticeship in Medical Physics

Clare Anderson (NHSEoE)

Background: There are well publicised workforce issues in medical physics which requires innovative thinking around new ways to bring additional workforce into the profession. Despite standards being approved for apprenticeship levels 2, 4, 6 & 7, the only apprenticeship available to the medical physics workforce was the Practitioner degree level 6 qualification with University of the West of England (UWE). The level 4 qualification is important to build our Healthcare Science Associate workforce but, with appropriate organisation, can also provide a route onto the Level 6 for employees who don't meet the entry requirements.

Methods: To open up additional opportunities into our profession all providers of HCS apprenticeships offering level 4 were approached. By garnering the opinion of the medical physics workforce, a provider, CSR Scientific Training group, was selected. Optional modules were chosen in conjunction with UWE to ensure the apprenticeship met the entry requirements for level 6 and the National School of Healthcare Science (NSHCS) as end point assessors.

Results: There has been interest across the medical physics workforce, and a pilot cohort has been setup and is due to start in August 2024. Further cohorts will be arranged for future years.

Discussion: The launch of this apprentice has been instrumental in raising awareness of apprenticeships across the medical physics workforce and increased understanding of the way they work, how they are funded and how they can be utilised across our profession. The launch meeting resulted in a request to

investigate setting up a level 7 apprenticeship which is currently underway with the NSHCS and an education provider.

Conclusion: To meet the continual workforce challenges in medical physics, it is vital that new ways of training are made available and utilised across the profession. Setting up a level 4 apprenticeship in medical physics has provided an additional route into our profession to help provide the medical physics workforce of the future.

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Machine Learning to Predict Full-Count PET Brain Scans to Aid Dementia Diagnosis

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Abstract

Individuals with suspected Alzheimer's disease or frontotemporal dementia may undergo a positron emission tomography (PET) fluorodeoxyglucose (FDG) brain scan in order to aid their diagnosis. Patient compliance can be challenging in these instances, where patients are known to leave the scanner prematurely due to disorientation associated with their condition, resulting in a low-count scan of non-diagnostic image quality. To address this issue, this study investigates using artificial intelligence (AI) to predict high-quality full-count PET brain images from low-count data. An image quality transfer(IQT) model was employed for this purpose, originally built for diffusion MRI brain scan enhancement [1, 2], however recently has shown great promise in the field of FDG-PET images [3, 4]. The IQT model uses machine learning to perform patch-based regression to map parameters from low quality to high quality images. 31 patient scans were used for this investigation, from which 4 low-count simulated images were reconstructed using list mode data, encompassing 5%, 10%, 30% and 50% of counts compared to the ground truth image. The AI performance on the low-count images was evaluated on a validation dataset of 6 patients using image fidelity metrics and a diagnostic outcome was given from an experienced radiologist with the aid of 3D-stereotactic spatial normalisation mapping (SSM). The AI was found to significantly improve the image quality for low-count scans that were ≤ 30% of the counts of the ground truth image, with a maximum increase of 4dB in the peak signal to noise ratio observed. A near-perfect agreement in diagnosis was obtained using the 5% count AI predicted scans compared to the ground truth images, prior to which all images would have been rejected due to non-diagnostic image quality. The results offer an initial indication that IQT is an effective technology in accurately predicting high quality FDG PET brain scans for cases where scans are non-diagnostic due to very low counts.

Key words: Positron emission tomography, PET, fluorodeoxyglucose, FDG, dementia, machine learning, AI

[1] Daniel . Alexander et al. Transfer via Random Forest Regression: Applications in Diffusion MRI. 2014

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[3] Ying-Hwey Nai et al. Validation of low-dose lung cancer pet-ct protocol and pet image improvement using machine learning. Physica Medica, 81:285-294, 1 2021

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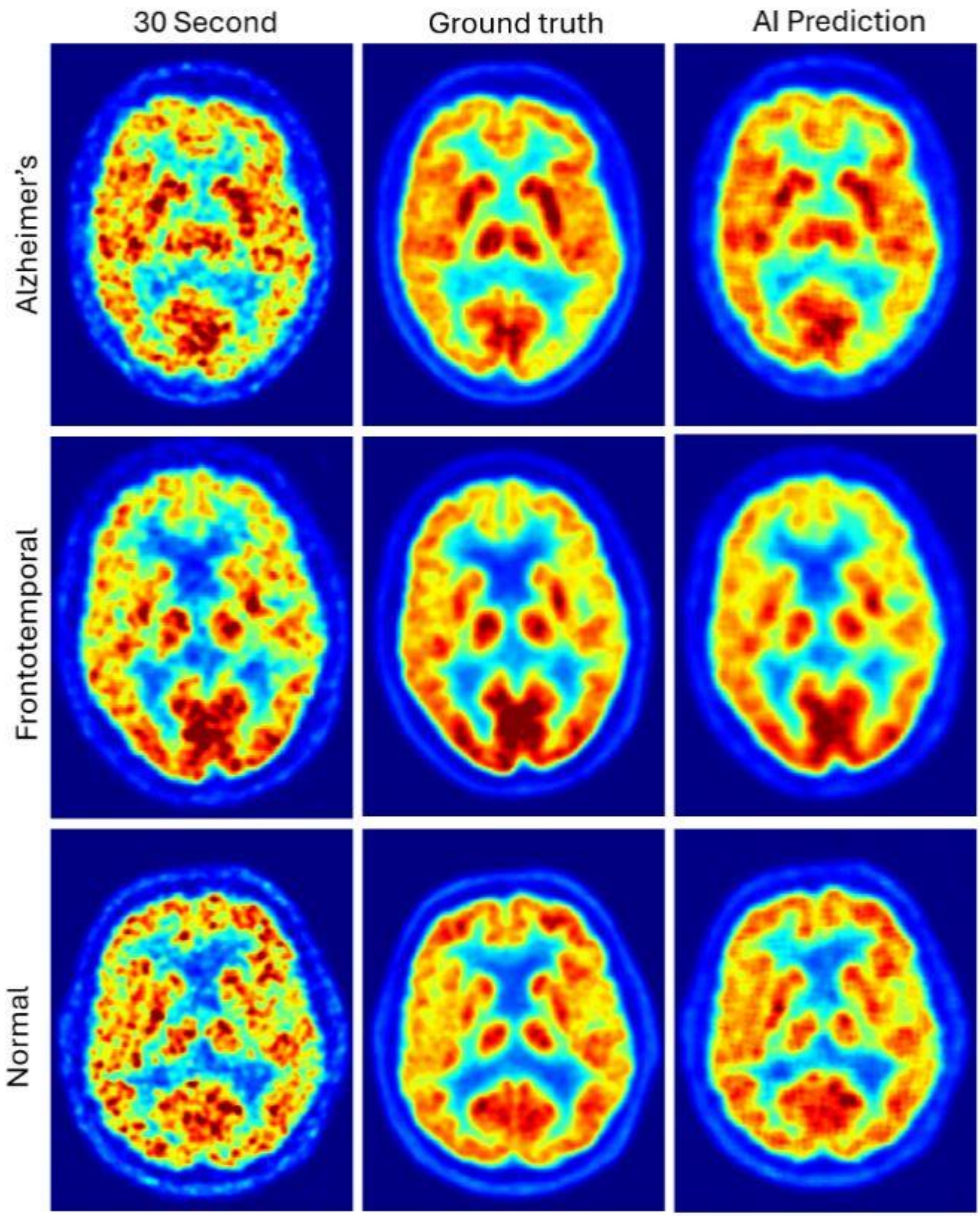
A figure from the study for interest (showing axial PET images of the brain for the low count 30 second input, the 10 minute ground truth scan and the AI prediction that used the 30-second scan as input).


30 Second
Ground truth
AI Prediction
Alzheimer's
Frontotemporal
Normal

7

Accuracy of Direct Dose Calculations on HyperSight CBCT Images for CBCT-Guided Online Adaptive Prostate Radiotherapy.

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Abstract

Background Advancements in imaging technology and AI have provided new solutions for online adaptive radiotherapy[1]. Varian's Ethos platform, for instance, uses deformable image registration between cone-beam CT (CBCT) and planning CT (pCT) scans to create a synthetic CT (sCT). This facilitates automated plan re-optimisation based on the anatomy of the day[2]. However, sCTs are prone to both geometrical and Hounsfield unit (HU) uncertainties[3,4]. Recent improvements in image quality and reconstruction algorithms have enhanced the accuracy of direct CBCT dose calculation[5].This study aims to determine whether direct dose calculation using Varian's novel HyperSight CBCT is dosimetrically accurate enough to replace the need for deformable image registration and generation of a sCT.

Method The CIRS mass density (MD) phantom (Model 062M) was used to create HU-MD calibration curves for reconstruction algorithms on HyperSight (including Acuros, iCBCT and Standard). Calibration curves were generated using the preset pelvis protocol on the IGRT imaging mode. Treatment plans were created on pCT scans of homogenous and anthropomorphic phantoms. CBCT to pCT registrations were performed, contours were copied, and the treatment plans on the CBCT were re-calculated.

Results The HU-MD curves closely match for soft tissue density materials but deviate at the extremities. The maximum HU deviation was 115 at a density of 1.53 g/cc. Dose calculations using HyperSight images for VMAT plans showed that dose-volume histogram values for CBCT images were within 2.0% for all reconstructions for both target and OAR structures. PTVDmean was within 0.4Gy (PTV_{median} 20.0Gy) for all reconstructions. 2D gamma analysis of an axial plane through the isocentre with a 2.0%/2.0mm criteria, global normalisation and 10% threshold, achieved passing rates of above 98.0% for all reconstructions.

Discussion The initial results of direct dose calculations on HyperSight images are promising. The deviation of HU values at high densities mean a correction factor for the HU-MD relationship will need to be introduced for calculations in data sets that include dense materials such as artificial joints. Further retrospective clinical validation will be required to conclusively compare the direct dose calculations on CBCT to sCT for prostate patient data.

Conclusion Phantom-based assessments confirm the accuracy of direct calculation on HyperSight images. The project will now move to retrospective clinical evaluation, investigating the accuracy of direct HyperSight CBCT dose calculations using clinical prostate data sets and comparing them to the sCT dosimetry which is currently used for online adaptive radiotherapy on the Ethos platform.

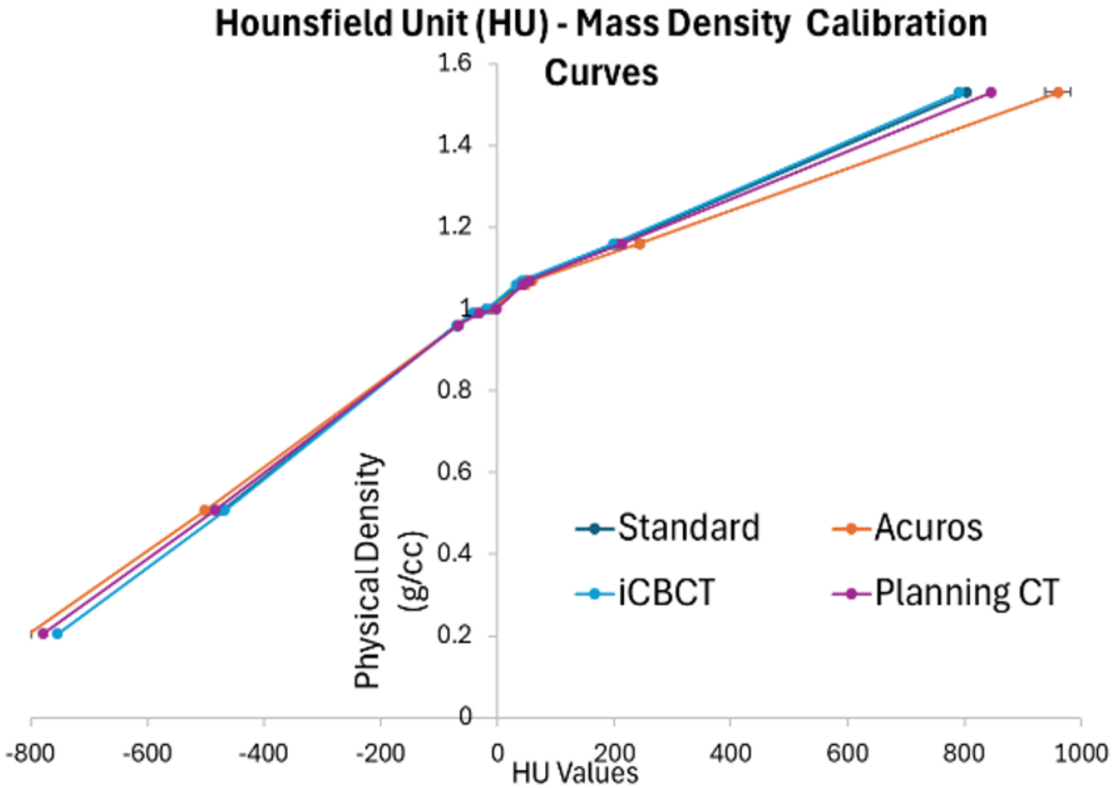

Figure 1 *plot showing HU density curves for different CBCT reconstructions and planning CT.*

References:

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Dosimetric impact of using structures derived using MVISION AI contouring software

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Abstract

Background.

In June 2023, the MSE Radiotherapy department implemented MVISION (San Antonio, Texas USA), a commercially available AI driven auto-segmentation software (MVISION, 2024), with the intention of reducing the time required to outline anatomical structures on CT images for Radiotherapy treatment planning. However, contrary to expectations, no significant time saving was observed in the months following the introduction of MVISION.

As previous works have shown that MVISION and similar auto-segmentation software can significantly reduce the amount of time taken for outlining (Doolan, et al., 2020) an examination of the departments use of MVISION was performed. This revealed that the operators responsible for reviewing and editing the contours provided by MVISION were performing extensive and time-consuming edits as there was a perception that outlines lacked the accuracy of the manual process.

This work was therefore commissioned to determine if the extensive editing was required and what effect it had on the treatment planning process for sites within the chest / thorax.

Methods.

Twenty patients who had recently received treatment were selected as test cases. For each case, the planning images were sent to MVISION, which generated new structures for the Heart, Lungs (left, right and combined), the Oesophagus and the Spinal Cord. These structures were then imported onto the treatment plan for comparison with those used during treatment planning, which were produced either through manual contouring or by editing a contour provided by MVISION.

The minimum, maximum and mean dose was recorded for each structure and the values from corresponding structures were compared to determine how the reported values differed between the original structures and those generated solely by MVISION.

Results.

The table below shows a summary of the obtained results. As can be seen, in the case of the Lungs there is little difference in the reported values. In the case of the Heart and the Spinal cord there appear to be some differences in the reported mean doses. Whilst a large difference is seen for the Oesophagus.

Structure	Mean Difference between MVISION Contours and Original Planning Contours		
	Minimum Dose	**Maximum Dose**	**Mean Dose**
Lungs	-0.24%	-2.98%	-0.80%
Heart	1.78%	-0.56%	6.27%
Oesophagus	5.40%	-28.87%	2.81%
Spinal Cord	2.67%	-1.81%	-5.96%

Conclusion.

The results obtained indicate that Lung structures produced by MVISION are adequate for treatment planning as are those for the Heart and Spinal Cord, following minor edits. The structures generated for the Oesophagus however require extensive editing.

Reliance on MVISION to provide the Lung contours should reduce the time required for outlining.

Key references.

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9

Development of a national community of practice for medical physics practice educators

Sarah Peel[1,2], Clare Anderson[3,4], Rosemary Eaton[1,5], Anna Vella[1,5], Lawrence Hutton[1,5], Danielle Cartwright[1,5], James Willsmore[6,7], Abigail Smith[6,8], Harry Poole[9], Neil Davies[10,11], Alex Goodall[12,13], Christie Theodorakou[14]

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Abstract

Background: From 2022, regional medical physics practice educators were seconded to NHS England to support increased training capacity in medical physics. We aimed to bring this group together, and include individuals in similar education roles, to form a national community of practice, allowing us to pool resources and co-ordinate our work for the benefit of the profession.

Methods: The medical physics practice educators each have different remits and work to regionally defined objectives. In July 2023, we set up a virtual community of practice. We meet every 6 weeks to share our work, get feedback from each other and plan joint initiatives.

Results: The community of practice has grown to include representation from all 7 regions in England. Examples of the collective outputs of the regional medical physics practice educator work are shown in the tables below:

STP initiatives
Regional supervisor network meetings to identify areas of the STP curriculum that could be delivered through workshops, online tutorials or other collaborative methods
Support for supervisors such as bespoke ‘train the trainer’ sessions
Development of consortium working e.g. for INIR rotation

Enabling delivery of INIR specialism between regions
Regional agreement on training plans including appropriate evidence expected for the new curriculum, with a particular focus on pared-down rotations
Gathering feedback from trainees and sharing with training centres
Pastoral support to trainees & signing off competencies
Sharing trainee/trainer support sessions (IACCs, reflective practice) across regions

Webinars and in-person events
Routes to Clinical Scientist Registration
Apprenticeships
Reflective writing for STP and Route 2 portfolios
HSST and HSS equivalence routes
MPE portfolios

Practice Educators also brought together training providers and trusts to develop a new level 4 medical physics apprenticeship, which will take its first cohort in 2024. In some regions, they have provided a professional interface between Imaging Training Academies and medical physics departments.

Discussion: Several practice educators have presented work at NHSCS events using shared learning and feedback from the community of practice. The community of practice has also been a quick way of gathering professional views from training centres on the STP and MSc programmes to feed back to the relevant organisations.

Sharing resources and outputs across regions helps to avoid duplication. By being a safe space, educators can share ideas with peers and work creatively, which is essential to make these roles effective.

Conclusion: To meet the workforce challenges in medical physics, we must support all training routes and levels. Practice educators provide support and expertise across their regional footprint. By collaborating together, we can extend this impact to a national level.

10

First estimate of the carbon footprint of PET imaging

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Abstract

Background. Climate change is acknowledged to be the single biggest threat to human heath in our century.[1,2] The healthcare industry in most industrialised countries contributes around 5% of the greenhouse gas emission of the country as a whole; the NHS is no exception. "Greener NHS"[3] is an initiative aimed at reducing the NHS environmental footprint, and has set targets of net zero by 2040. There is however no literature that estimates the emissions of clinical molecular imaging; this work begins to address this.

Methods. Activity at the PET department at Paul Strickland Scanner Centre, Mount Vernon Hospital, was audited, and activity data converted to estimate the carbon footprint in kg CO_2e per patient scanned. Since the majority of the work was FDG or PSMA oncology imaging, no attempt was made to differentiate between scan types.

The following parameters were measured:-

- power use of scanners (available on two of the three scanners audited), kWh
- power use of ancillary equipment, including the auto-injector, kWh
- consumables used and waste generated, kg
- patient and staff travel and modality, road miles

In all cases, BEIS data[4] were used to convert activity data to kg CO_2e.

Results.

The data from one of our scanners is shown in fig 1. Note that the scanner power also includes the idle power taken when the equipment is not in use; it was derived from electricity meter readings taken over a month, divided by the patient throughput in that month. The total emissions from operation of this scanner were 17.6 kg CO_2e per scan.

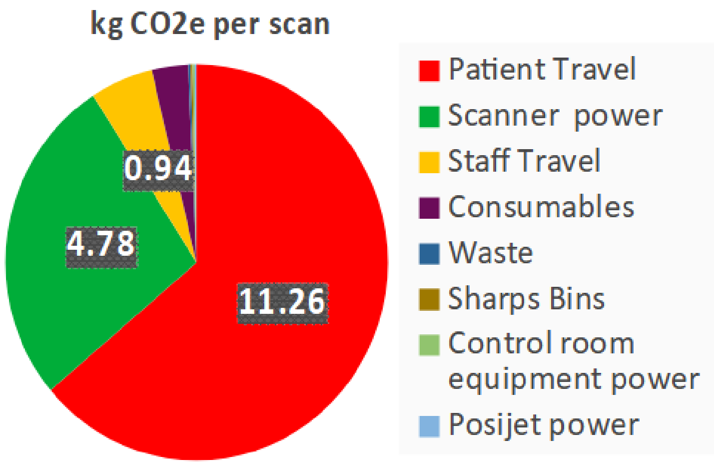

Fig 1: Summary CO_2e data from a Siemens Biograph mCT; values in kg CO_2e per scan; labels apply to the three largest contributors

Discussion.

The major factors in CO_2e emission are seen to be patient travel and scanner power.

- The vast majority of patients travelled by car; bus and train travel was used by 6% of patients; BEIS data show that bus and train travel emit between 5% and 15% of petrol car emissions over the same distance.
- Data are also available for an older scanner, which was shown to use 33% more power. This result highlights to manufacturers the need to optimise scanner power use, and indicates that idle power must also be considered.
- The impact of production and delivery of the tracer was not included. Manufacturers do not currently appear to have these data, and are encouraged to develop suitable metrics as soon as possible.

Conclusion. This study provides initial data relating to the carbon footprint of PET imaging, highlighting two key areas for consideration for carbon reduction strategies: patient travel and scanner power use.

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[3]https://www.england.nhs.uk/greenernhs/

[4]https://www.gov.uk/government/publications/greenhouse-gas-reporting-conversion-factors-2023

Key words

sustainability, imaging, carbon footprint

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11

Effectively MR Conditional Cardiac Implantable Electronic Devices

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Abstract

Background. Many modern Cardiac Implantable Electronic Devices (CIEDs) are labelled MR Conditional. This means the pulse generator and leads have been tested by the manufacturer and shown to be safe to scan under certain conditions. However, manufacturers don't routinely, retrospectively test older components and components from other manufacturers. This means many patients have CIEDs which are MR Unlabelled, meaning their device is untested (but not necessarily unsafe) in the MR Environment.

A patient specific risk assessment is recommended when scanning an MR Unlabelled active implant [3]. This can lead to delays to scanning. However, the joint British society consensus recommendations for MR imaging for patients with CIEDs [1] provides a comprehensive list of MR Unlabelled scenarios where the risks related to scanning are comparable to scanning an MR Conditional CIED.

Methods. With the aim of widening access to MRI, an effectively MR Conditional (e-MR C) procedure was developed. A limited number of low-risk scenarios (all including an MR Conditional pulse generator) were defined as e-MR C and an overarching risk assessment was performed, meaning patients with e-MR C CIEDs don't have to go through a patient specific risk assessment.

The e-MR C procedure was introduced at two Trusts in February 2023 and one in February 2024. The impact of implementing the e-MR C procedure on CIED referrals was assessed by recording the proportion of patients with e-MR C CIEDs who were approved for MRI before and after the e-MR C procedure.

Results.

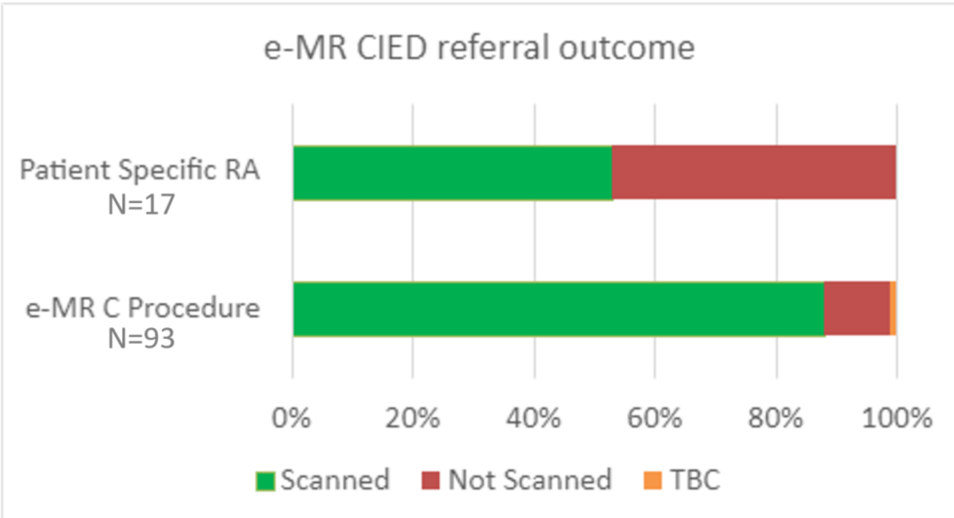

Figure 1 Outcome of referrals for patients who have e-MR C CIEDs, at Trusts which now operate under an e-MR C procedure.

Discussion. Patients were more likely to receive a scan after the e-MR C procedure was introduced. Implementing the e-MR C procedure has increased confidence in scanning low-risk CIEDs off-label among radiographers, radiologists and cardiac technologists. As the evidence body related to scanning CIEDs off-label grows, there is scope to expand this procedure nationwide.

Conclusion. The effectively-MR Conditional procedure has simplified the safe scanning of patients with low-risk MR Unlabelled CIEDs, widening access to MRI for these patients.

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12

Effective training of the workforce for online adaptive radiotherapy, with particular reference to a career development path for Dosimetrists.

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Abstract

Background. Mid and South Essex Foundation Trust (MSE) have recently acquired an Ethos (Varian) treatment unit which supports online Adaptive Radiotherapy (oART). Staffing at MSE, as in many UK departments, is under-established for all staff groups. A training strategy was developed, that also allows for career development for Dosimetrists.

Methods.

An understanding of the processes involved in oART was essential in being able to establish a gap analysis of the skills within the department. Once the processes were mapped out, a skills gap matrix was built for each staff group. Following this, we set up a training program to fill the skills gaps.

It also became clear very early on that Consultant Clinical Oncologists (CCOs) would not be able to attend each fraction of oART for a patient due to ongoing staffing shortages. We would therefore be relying on other staff groups to make decisions at the treatment unit each day, and therefore an expansion of the training program was required. Dosimetrists are particularly suited for many of these tasks due to their background in plan evaluation and skills in outlining. As many Dosimetrists aren't able to access the formal career progression possible for many of their peers; this was seen as an appropriate route for structured advancement for senior dosimetrists in the department.

Results.

The training program for staff groups included:

- The utilisation of the Proknow Contouring Academy to train both Dosimetrists and Therapeutic Radiographers in OAR outlining. Each trainee had a personalised training plan specifying the organs that they were to be trained on.
- 1:1 training provided by CCOs to dosimetrists on target outlining
- Attendance at external courses.

Discussion.

Career development for Dosimetrists has historically been difficult to formalise, in part due to the many different entry points into the role. One of the promising ways that a career structure can be developed for Dosimetrists is in utilising their skills in the analysis of treatment plans, to make decisions during an oART treatment to select the most appropriate plan for treatment.

Conclusion.

The training package developed at MSE aims to develop the skills recognised as missing for oART with Ethos.

With appropriate use of skills mix, we have developed a career route for Dosimetrists and provided skills to allow flexibility in treating patients with oART.

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SCIENCE, TECHNOLOGY & ENGINEERING FORUM

13

Results of an environmental sustainability survey of radiotherapy professionals: a UK physicist sub analysis

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Abstract

Introduction
Climate change is a worsening crisis that will affect people's health and consequently healthcare within the UK and globally. To gain an understanding of UK radiotherapy physicists views on the contribution of our profession on and to climate change a sub analysis of a wider European SocieTy for Radiotherapy and Oncology (ESTRO) survey was undertaken.

Methods
A survey of ESTRO members was created that asked questions about the environmental impact of radiotherapy services, their personal actions and expectations of ESTRO's responses to the climate crisis. The survey was promoted to everyone on ESTRO's mailing list and achieved 707 responses. A sub analysis of the responses from radiotherapy physicists living in the UK (61 responses) has been analysed here using Microsoft Excel.

Results
94% of UK radiotherapy physicist respondents either strongly agree (53%) or agree (41%) that climate change is a concern with 90% saying that they had made changes in their personal lives to help fight the climate crisis.

36% of UK radiotherapy physicists said that they liked online conferences but 87% of respondents agreed that offering more digital participation in conferences and meetings should be a priority. Out of the options given for potential barriers for increasing the use of digital access to ESTRO conferences, the most popular response was 'It reduces networking opportunities' (88.5%).

There was an acknowledgement by the respondents that whilst they didn't like online conferences and meetings that they were necessary to reduce our carbon footprint. 29% of respondents said they would be prepared to travel up to 6 hours by train to an international/national conference. When considering meetings in the UK, those that are reachable by train within 6 hours vary greatly with location (see Figure 1)[1].

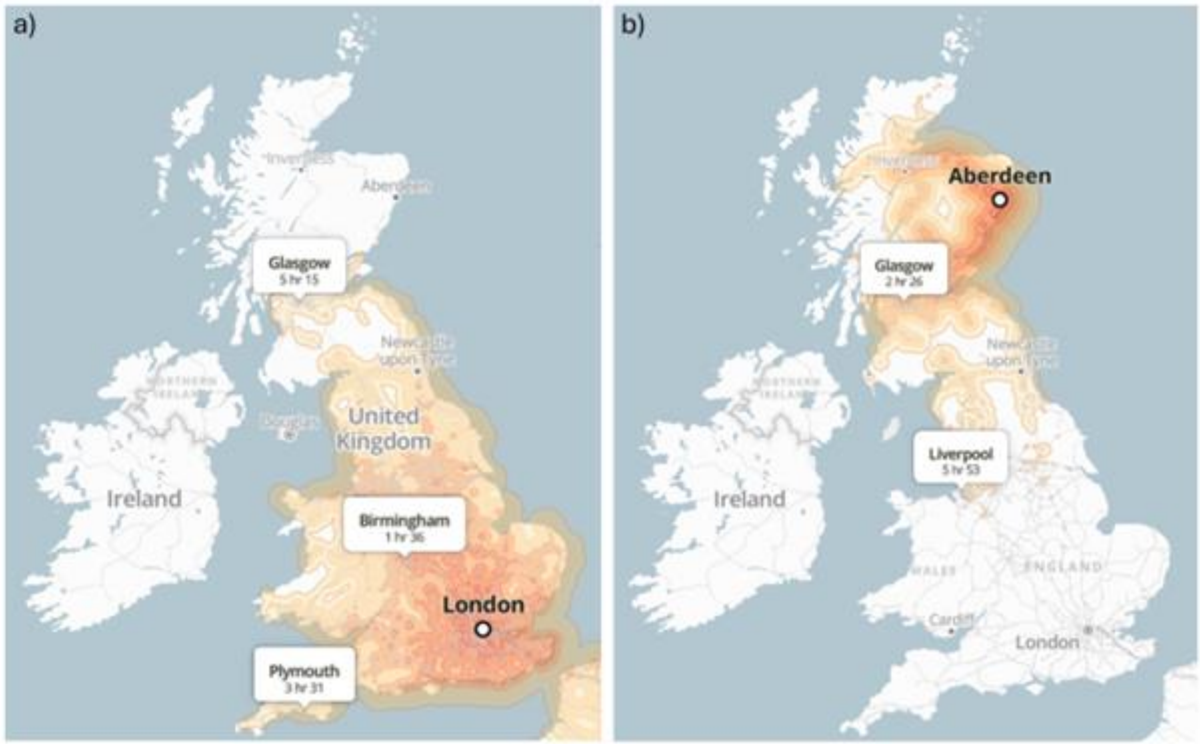

Figure 1) Maps of UK locations within 6 hours train travel from London (a) and Aberdeen (b)[1]

Among the respondents there is a large call for organisations to be increasing engagement with manufacturers around environmental sustainability. This could be done by helping make their treatment machines more energy efficient, produce less waste and reduce the need for SF_6.

Whilst this survey wasn't directed at UK radiotherapy physicists alone, it may still offer us a good idea of the thoughts of IPEM's members on these matters and the priority people give to it. Biases cannot always be removed, with the possibility for e.g. that those that are more concerned about the climate crisis are more likely to respond.

Conclusion

Our results indicate a clear concern about the climate crisis among UK radiotherapy physicists and a call for organisations to make changes in response to the climate crisis in terms of both the manufacture of treatment machines and access to conferences.

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14

Developing a framework for improving environmental sustainability in radiotherapy

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Abstract

The NHS has set to achieve a net zero carbon footprint by 2040[1], which will require proactive measures from all departments. Radiotherapy and oncology are included in this shared responsibility, necessitating participation from all disciplines. An Environmental Sustainability Working Group was formed under the Radiotherapy Board consisting or IPEM, RCR and SCoR members aiming to educate and enact changes to make radiotherapy greener.

The Royal College of Emergency Medicine's GreenED initiative has established a bronze, silver, and gold framework portal providing emergency departments with actions to reduce their climate footprint[2]. This model was adapted to fit a radiotherapy department, and various sources of carbon emissions were researched, including patient travel[3], LINAC energy use and SF_6 leakage[4], medical waste[5], and data storage[6]. Actions to reduce the impact of these factors were then considered.

The actions were categorised bronze, silver, or gold based on the likely magnitude of change to current practice and potential benefit. Bronze actions were designed as 'quick wins', with relatively little cost, effort, or time required to implement. Silver actions would require more active participation from the department and are expected to take longer to implement, while gold actions may result in a significant change to current practice but should yield the greatest impact. Departments following this framework can provide evidence of completing these actions and gain accreditation to the respective level.

This framework is being piloted in a small number of radiotherapy departments and will be continually adapted based on feedback and ongoing reserach, with the aim to scale up to other centres. Adopting these actions may initially be met with resistance, especially with the currently stretched NHS workforce. However, this framework can provide guidance for departments to improve their environmental sustainability in manageable steps, with accreditation offering both a rewarding incentive and good publicity.

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15

Single departmental experience of implementing the "Greener NHS" sustainability ambitions.

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Abstract

Background

Climate change, and other environmental issues, represent the single biggest threat to human health[1,2]. The NHS has set targets for reaching net zero with "Greener NHS" working with staff, hospitals and partners to achieve this. This abstract discusses the experiences of one department working to reduce the footprint of medical physics from 2021 to the present.

Methods and Results

Raising awareness: staff in the medical physics department contributed to a 2021 Trust-wide survey which found 91% of responders considered "sustainability and environment issues" as extremely or very important; 92% considered it extremely or very important that the Trust act on these issues. However, 44% were not at all aware of Greener NHS net zero ambitions. Changes were made including adding sustainability to staff meetings and introducing a talk in staff induction.

Energy usage: Trust-wide initiatives ensure power is supplied from green tariffs and solar panels have been installed over two of the main hospital buildings, including the radiotherapy department producing about 110 MWh/year. Small demand reductions have been achieved through turning off equipment and air conditioning when not in use, where appropriate. Selection of new radiotherapy equipment (Varian Halcyon units) designed to draw much less power than the predecessors will produce further reductions.

Procurement: Department staff are aware that "Greener NHS" initiatives mandate "carbon reduction plans" for suppliers. However, the specialist nature of medical physics and clinical engineering equipment and lack of competition appears to reduce pressure on manufacturers to optimise the sustainability of their operations.

Waste: department staff have engaged with manufacturers and suppliers concerning design, use and total volume of packaging, the fraction that is recyclable, and the cost of transport (related to the CO_2e that will be emitted during transit). While all parties were keen to engage there has so far been no change in manufacturer packaging achieved. This is partly due to the cost of re-certification of packaging after any form of modification.

Sustainability research: staff members have been funded to allow dedicated time to lead sustainability research. The department is running a study to calculate the carbon footprint of molecular imaging and is running another project to investigate carbon reduction possibilities in head & neck radiotherapy pathways.

Discussion

There is significant staff concern regarding environmental issues and growing awareness of the "Greener NHS" ambitions. Within medical physics and clinical engineering there are difficulties in achieving significant improvements in environmental sustainability at departmental level.

Conclusion

Major improvements in sustainability have resulted from Trust-wide initiatives with departmental projects adding smaller additional gains. The bigger impacts from the medical physics department are expected from research by funded staff members with outcomes that can be applied nationally and internationally.

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16

Increased Patient Throughput via Implementation of Artificial Intelligence in Diagnostic MRI

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Abstract

Background. In 2021, NHS England and Improvement (NHSEI) procured Advanced Acceleration Technology (AAT) to increase MR scan capacity by at least 10%. Thirty scanners across twelve Trusts in North-West England supported by Christie Medical Physics and Engineering (CMPE) MR physics group benefitted from the funding award. Artificial Intelligence (AI)-based AAT from three manufacturers: Siemens (*Deep Resolve Gain, Sharp and Boost* [1]), Philips (*SmartSpeed* [3]) and GE (*AIR Recon DL* [4]) was installed on nineteen of these scanners. This software uses deep learning during image reconstruction to remove noise and artefacts and/or improve spatial resolution leading to shorter acquisition times as diagnostic image quality is achieved with fewer data points [2].

Methods. Figure 1 summarises the optimisation project workflow developed by NHSEI North West in collaboration with and implemented by CMPE MR Physics. The goal was to accelerate existing sequences using AAT whilst maintaining image quality to reduce appointment slot lengths.

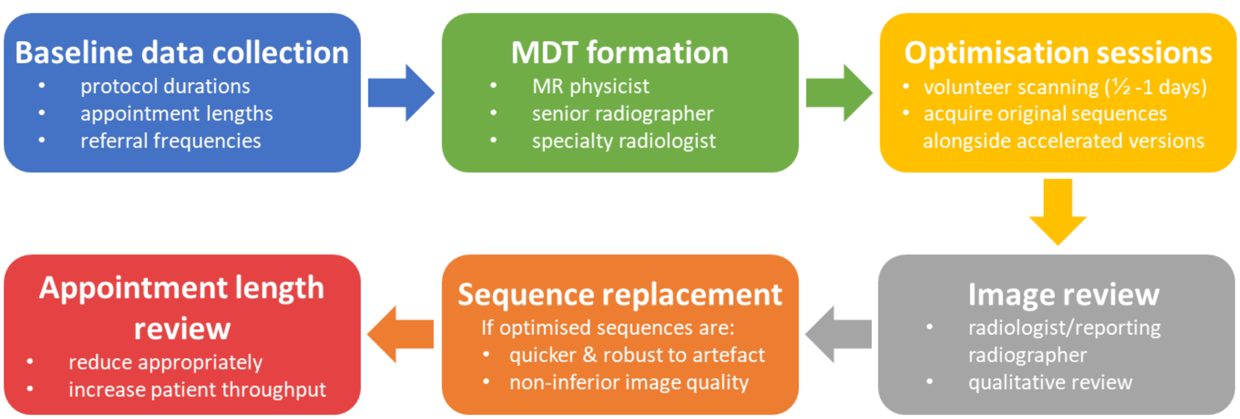

Figure 1: The optimisation project workflow summarising the steps to using the implementation of AI technology to reduce appointment lengths leading to increased patient throughput.

The difference in appointment lengths pre- and post-optimisation were used together with the annual average referral numbers for each protocol to calculate an estimated number of extra 30-minute slots generated.

Results. A total estimated additional 16,040 30-minute slots per year were generated across eighteen scanners with AI-based AAT, an increase of 18.8%. One scanner was excluded as appointment slots are yet to be reduced for clinical reasons. Figure 2 shows the estimated additional capacity for fifteen systems.

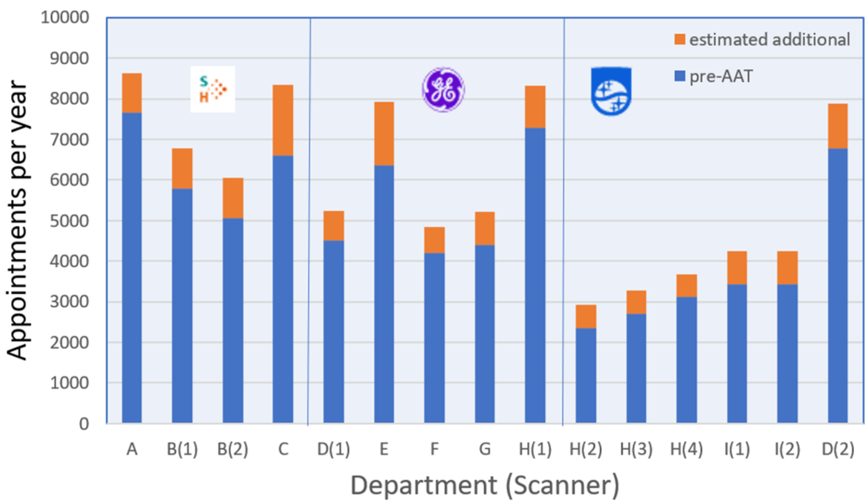

Figure 2: Estimated number of additional 30-minute examination slots generated with manufacturer-specific AI-based AAT alongside estimated pre-AAT throughput. Fifteen scanners across nine Trusts are included. Three scanners were excluded from the figure as pre-AAT throughput data were not available. One scanner was excluded as the appointment slots have not yet been reduced for clinical reasons.

Discussion. The estimated 18.8% increase greatly exceeded NHSEI's 10% target. The one-off cost of the eighteen licences and associated hardware upgrades was £2.74 million. The projected increase demonstrated good return on investment compared to outsourcing to the private sector, which for the equivalent capacity increase is estimated to cost £1.87 million per year. Other benefits include improved patient experience and more manageable patient lists for MR departments. Challenges included the large time investment for MR physicists, securing scan time for the volunteer sessions, obtaining image reviews, and accurately quantifying the project's outcomes across Trusts. The complex real-world patient throughput data are beyond the scope of this abstract but preliminary data suggest these estimates are sensible.

Conclusion. The above-target capacity increases demonstrate how MR physics teams can drive MDT projects robustly and efficiently, reducing patient backlogs by implementing new AI technologies whilst maintaining diagnostic image quality. This rapid multi-site implementation should be considered when implementing AI technologies nationally.

Keywords. *AI, MRI, image optimisation.*

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17

Initial Estimate of the Carbon Footprint of Brachytherapy in the UK

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Abstract

Background:

Climate change is acknowledged to be the single biggest threat to human health in our century[1,2]. Healthcare is responsible for 4-5% of the UK's carbon emissions and the NHS was the first healthcare service to embed net zero into its legislation with the Health and Care Act 2022. The UK & Ireland Prostate Brachytherapy Users Group meeting highlighted there is little literature on the sustainability of UK brachytherapy, and established a group to perform a multi-centre audit of the environmental footprint of the brachytherapy process.

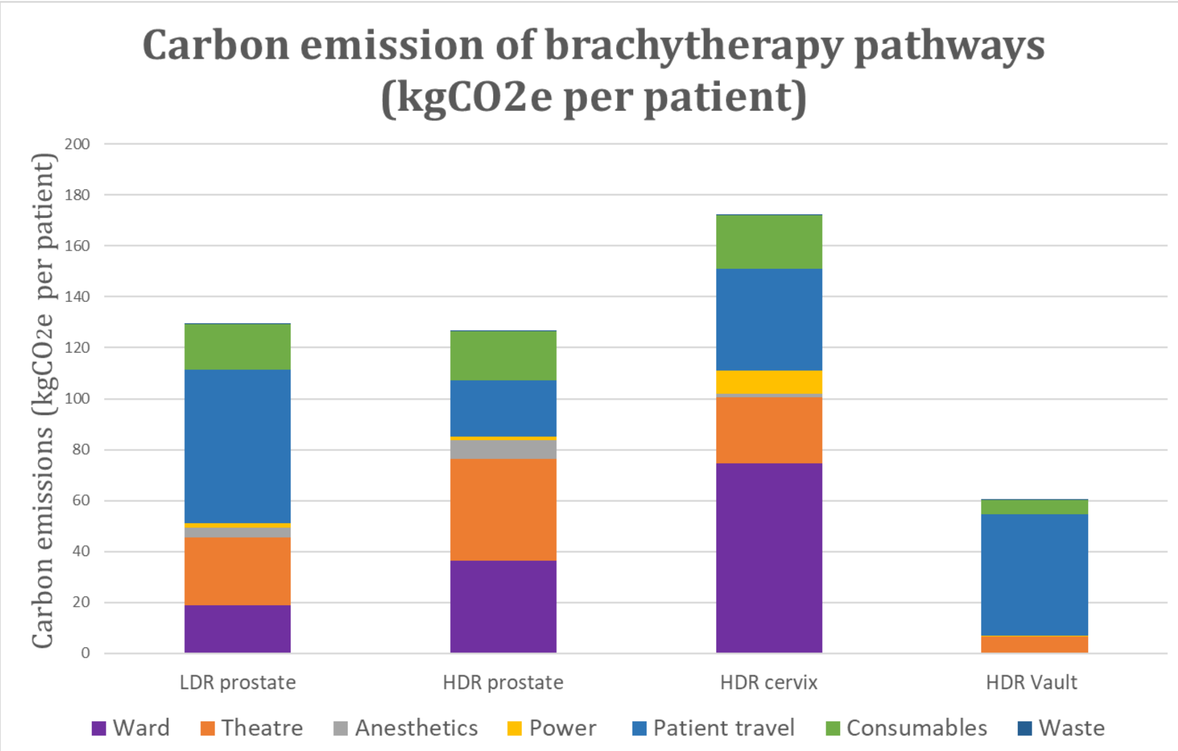
Method:

9 centres collected data for four brachytherapy pathways: HDR prostate, LDR prostate, HDR cervix and HDR vaginal vault. Data collected concerned power use from imaging and treatment machines, power use from time on wards and in theatre, anaesthetics, consumables waste and patient travel. Emissions from the overall process were quantified by itemising each component of the process, and using relevant conversion coefficient in units of $kgCO_2e$ per unit of activity derived from BEIS data[3], and data from Greener NHS[4]. Results were expressed as $kgCO_2e$ per course of brachytherapy.

Results:

HDR vault had the lowest associated emissions (60 $kgCO_2e$ per patient). This is expected as vault patients spend little, if any, time in theatres and wards. LDR and HDR prostate had similar carbon emissions per patient (130 kg CO_2e and 127 kg CO_2e respectively), and HDR cervix had the largest (172 kg CO_2e per patient).

Patient travel was a significant contributor in all pathways, particularly LDR prostate (47% of total CO_2e for the pathway) and HDR vault (79%). Theatre and ward time contributed between 35% and 60% for pathways other than vault, and consumables contributed a similar amount (10-14%) in each pathway.



Discussion:

This work aimed to estimate the footprint of various brachytherapy pathways as a baseline for further studies, and to identify areas where efforts to mitigate can be focused. There are some significant differences between centres that arise from the catchment area of the centre, the choice of anaesthetics and whether or not patients are kept as day or overnight cases. Some coefficients relating activity data to CO_2e have significant uncertainties as they are based on 'typical' situations that may not be directly applicable, but this still provides an idea of relative impact. Emissions during manufacture, disposal and transport of sources are not included, nor staff travel, but both may be significant meaning the absolute numbers are likely to be much higher.

Conclusion:

The major contributors to carbon footprint appear to be patient travel and time spent on wards and in theatre. This study will be useful as a pilot to the larger ESTRO brachytherapy footprinting study.

References:

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Key Words: Sustainability, carbon footprint, brachytherapy, radiotherapy

Upskilling MR radiographers with physics-led, simulator-based training

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Abstract

Background

To meet growing demand for imaging services, there is need to train and upskill significant numbers (4000) of radiographers and sonographers[1]. MRI physics (and scanning) is not comprehensively covered in undergraduate teaching, resulting in significant learning on the job for MR radiographers. Efficient training is key to meet workforce demands; the Richards report highlights use of scanner simulators and effective collaboration across imaging networks to achieve this[1].

Methods

The Christie Medical Physics and Engineering (CMPE) MR Physics Group, collaborating with the North West Imaging Academy (NWIA), developed and delivered an MR physics training course for early career radiographers, using Corsmed MR simulator software[2]. Corsmed is a vendor agnostic, online MR scanner simulator. The course blends taught content and practical exercises on the simulator, delivering the fundamentals of MR physics for an MR radiographer audience. Every attendee had individual access to the simulator; these licenses were funded by NWIA. The course has been held five times over the past year at NWIA radiology satellite sites, with 21 radiographers attending two pilot courses in 2023, and 39 at three three-day courses in 2024.

The effectiveness of the course was assessed using attendee surveys before and after the course, self-grading their knowledge and understanding of fundamental MR concepts (on a scale from 1 “Very Poor” to 5 “Excellent”), and perceived course quality.

Results

The self-reported overall improvement was from 2.1 to 3.85 in the pilots and 2.48 to 4.04 in the 2024 courses. This improvement was reported consistently across all areas covered by the course (Figure 1).

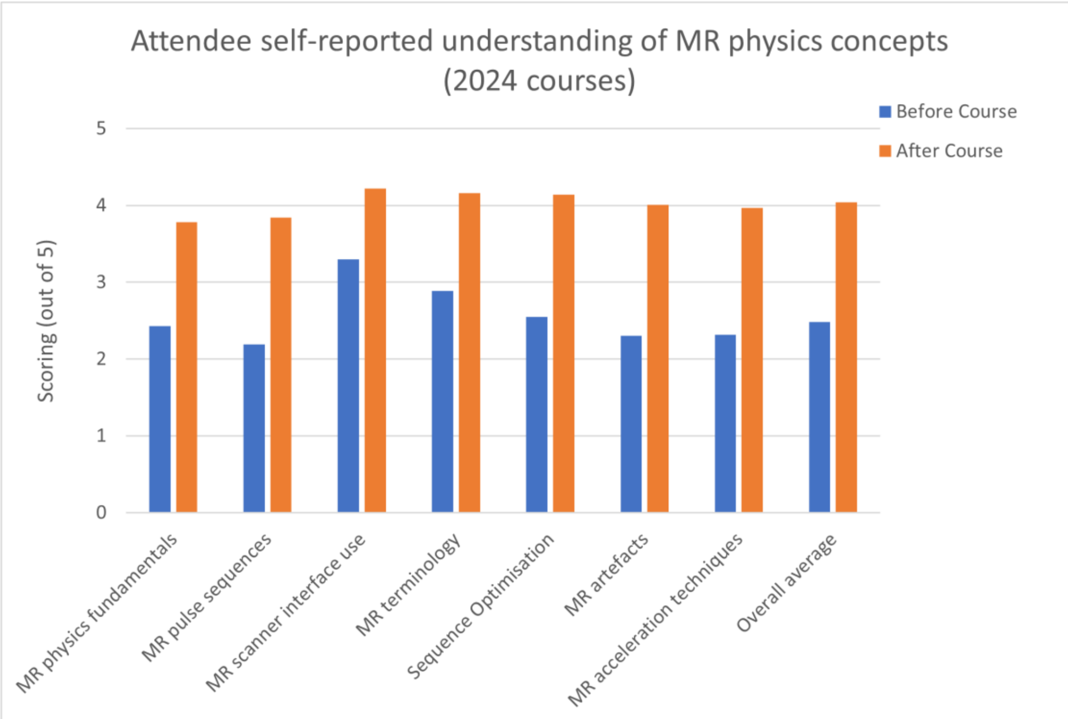

Figure 1: Self-reported understanding of MR physics concepts that were covered by the MR simulator course. Attendees scored this before (blue) and after (orange) the course.

The course was well rated by attendees (Figure 2).

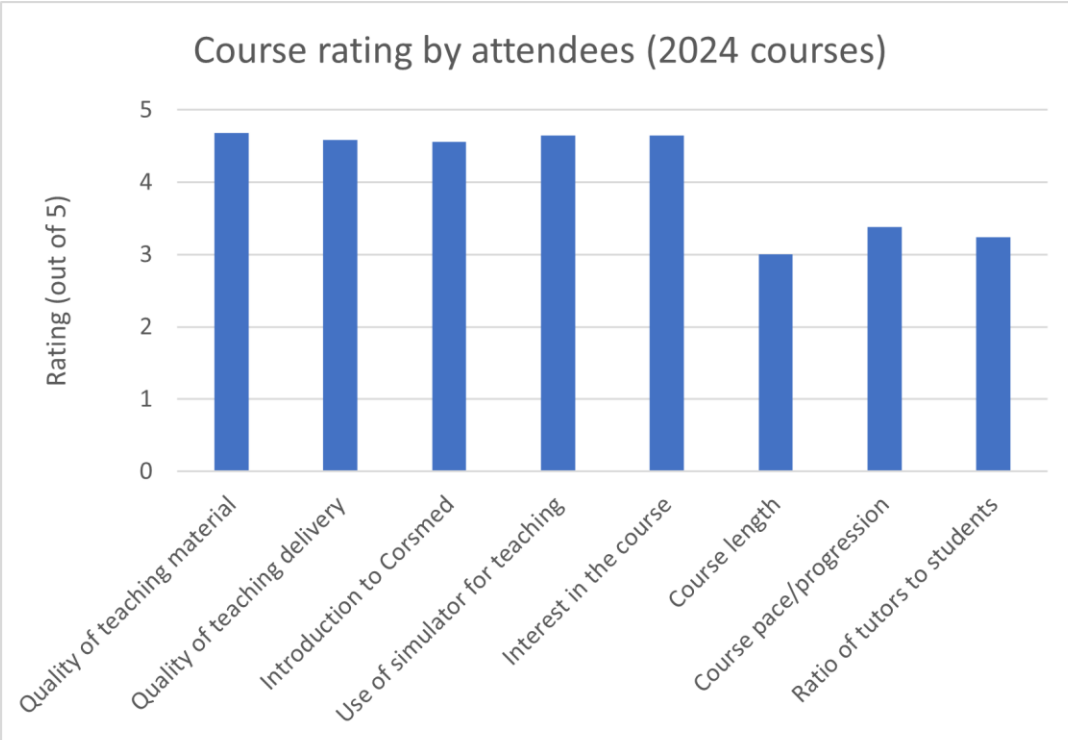

Figure 2: Attendee rating of the MR simulator course.

Discussion.

The attendee feedback suggests that the course was effective in upskilling MR radiographers in physics relevant to their role, and the Corsmed simulator facilitated their learning. We found that the simulator enabled realistic demonstration of concepts being taught and put the physics into meaningful context. Additional long form feedback suggested that some previous MR experience made the course more beneficial.

There were a few challenges in delivery of the course as the simulator software is still in active development; we have been feeding back to Corsmed about these issues.

The course was focussed on the MR Physics aspects of radiographer training; further development to the course/training would include patient positioning, coil selection and scan planning.

Conclusion.

CMPE have successfully developed and delivered simulation-based courses to enhance the MR physics understanding of early career radiographers in the North West. MR radiographers and their managers have reported strong improvement in the understanding of MR physics and pulse sequence parameters from the course. There are discussions underway to share this training model across other NHS regions.

References.

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19

Quantifying hesitation and smoothness in prosthetic patients in important functional tasks: sit-to-stand and sit-to-walk

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Abstract

Background
Quantitative gait analysis is not routinely used with amputees due to limited knowledge on the amputee gait, the timing and cost implications of data acquisition and processing and the impact of prosthetic componentry [1,2]. However, measures of movement fluency (hesitation and smoothness) can be obtained from one C7 marker and could overcome these issues [3,4]. In prosthetic assessments, physiotherapists make subjective observations of movement fluency however, this relies on extensive experience. Sit-to-stand (STS) and sit-to-walk (STW) are important tasks to complete activities of daily living, and key functional tasks to master following amputation [5]. This study aims to establish quantitative measurements of movement fluency in amputees.

Methods
12 transfemoral amputees (6 limited community ambulators and 6 community ambulators) completed walking, STS and STW. Movement fluency was assessed using algorithms outlined by Kerr [3] and Chandler [4] to obtain hesitation and smoothness. Comparisons were made between the groups and relationships to walking speed were explored.

Results
The community ambulators were significantly faster in walking. In STW, the community ambulators were significantly less hesitant and smoother than the limited community ambulators. In STS, the community ambulators were significantly smoother. The STS hesitation algorithm, previously used for stroke patients, was not suitable for the prosthetic population. No strong relationships were found between movement fluidity and walking speed.

Discussion
Hesitation and smoothness could be associated with reduced muscular strength, or lack of confidence or balance. The reduced hesitation and increased smoothness of the community ambulators is likely due to increased functional activity levels. They are likely to be performing these tasks more regularly building up strength, postural control and technique. Walking speed is known to differentiate amputees of different functional levels. The lack of correlation to walking speed suggests that STS, STW and walking speed all require specific training following amputation. Hesitation and smoothness could be used to classify patients. This study has started the process of automated classification of amputees using advanced instrumentation and k-means clustering.

Conclusion

Assessment of movement after amputation is not just about speed. Other important functional tasks should be considered. Quantifying movement fluency in functional tasks is important to understanding the restoration of function following limb loss and tracking rehabilitation.

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20

Initial estimate of the carbon footprint of UK proton therapy services

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Abstract

Background: The NHS is aiming for net zero for emissions directly within its control by 2040. Work is underway in radiotherapy to establish the carbon footprint of services, but for proton therapy, just one study worldwide has been published, which estimated the carbon footprint of power consumed by Orlando Health Cancer Institute high energy proton service as 253.7t CO_2e/year[i] and from patient and staff travel to be 190t CO_2e/year[ii]. The aim of this study was to establish the carbon footprint of three UK proton therapy services in order to:

1. Identify the largest contributing factors to guide the most effective carbon reduction
2. Provide a baseline to measure carbon reductions against
3. Identify similarities and differences between the centres, helping to identify opportunities for carbon reduction

Methods: A carbon footprinting study was established at Clatterbridge Cancer Centre, The Christie, and University College Hospital. A process-based approach was carried out with data collected on each key carbon contributing element of the service. Greenhouse gas conversion factors were then used to convert values established into carbon dioxide equivalent (CO_2e) weights.

Results: The CO_2e of the proton service at Clatterbridge was estimated as 331t annually, equating to an average of 1,095kg per patient.

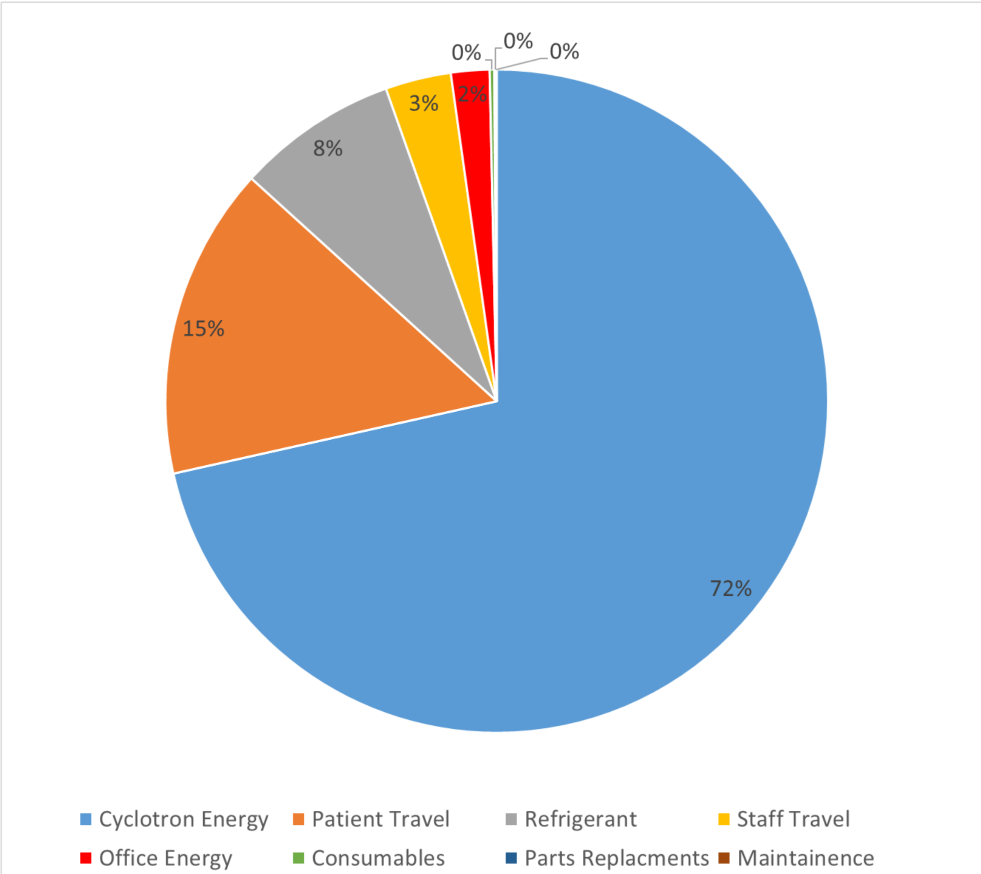

Figure 1 – Breakdown of the sources of the Clatterbridge proton service carbon footprint. Electrical power accounted for 236t CO_2e (72%) annually.

Initial data from the Christie also indicates that electrical power is the key factor, estimated as 441t CO_2e annually.

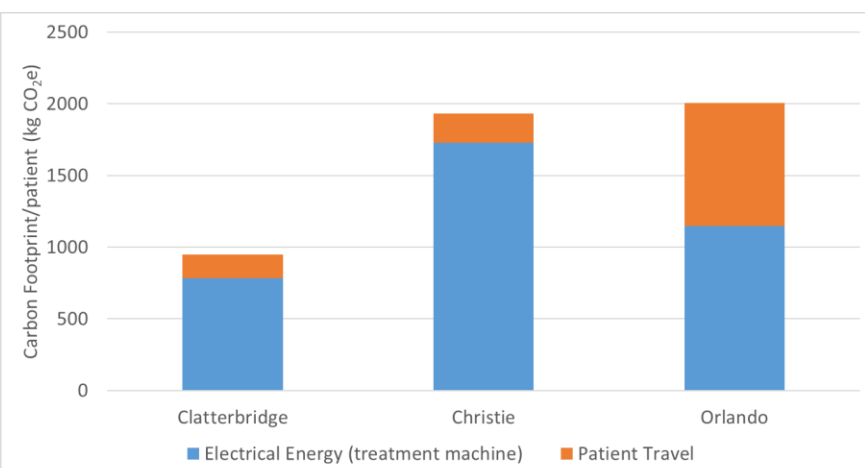

Figure 2 – comparison of the CO_2e of the two major contributing elements for three proton centres.

Discussion: On a per-patient basis, proton therapy is estimated as significantly more carbon intensive than linac-based radiotherapy. Results indicate that electrical power is the largest contributor to carbon emissions of a proton therapy service. Annual emissions from electrical power were estimated to be similar to the published US study on a per patient basis. UK patient travel contribution was significantly less than electricity but still high. Reductions in this area are likely to rely upon the decarbonisation of travel, although green travel incentives and local accommodation provision could help.

Conclusion: A bottom-up carbon footprint estimation has been made for the Clatterbridge Cancer Centre proton therapy service as 331T CO_2e annually, of which 72% is attributable to electrical power. Electrical power at The Christie Proton Therapy Centre is estimated to emit 441T CO_2e annually. A switch away from fossil fuel generated electricity is likely to have the biggest impact on CO_2e reduction in proton therapy. A baseline estimate of the carbon footprint of a UK proton centre has been established with work ongoing to extend this.

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Evaluation of cervical PTV margins for online adaptive external beam radiotherapy.

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Abstract

Background: The aim of this study was to retroactively derive, apply and evaluate the effectiveness of two alternative uterus planning target volume (PTV1) margins, for cervical online adaptive radiotherapy (oART) treatments, on a Varian Ethos linear accelerator (linac). The two alternative margins for PTV1 were bespoke, patient specific margins and a population margin.

Methods: The approach of this study was to use the images and plans from 19 patients who have a total of 459 fractions treated with oART. The margins were derived from measurements of intra-fractional motion, taken as the largest deviation in the CTV1 position in two CBCTs prior to treatment. The margins were then applied to patient structures and the treatments was re-planned using each of the alternative margins. The benefit to normal tissue and the target coverage was assessed through comparison of the generated plan's OAR and target dosimetry.

Results: The alternative margins were found to reduce OAR dose metrics from plans with the standard margin by up to 18%, with minimal change (<±0.3% in all metrics) to target dosimetry. Geometric coverage probability was calculated as the percentage of fractions where CTV motion during treatment, measured by two CBCTs, did not go beyond the chosen margin. Both bespoke and population margins gave a sufficient probability of CTV coverage, 98% and 95% on average.

Discussion: While the overall coverage percentage of each margin was acceptable, the smaller population margin had 1 patient with 9 of 28 fractions showing intra-fractional motion beyond the limits of the PTV. This would not be clinically acceptable, but physicists routinely review each fraction, so the margin would be altered for this one patient after reviewing the first few fractions.

Conclusion: The population margin was concluded to be the most clinically useful, due to improved dosimetry and lower workload to routinely use the margin. A recommendation of reducing the standard margin for cervical oART treatments has been made to the lead gynaecology consultant oncologists at the trust.

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How to Implement AI into Breast Screening

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Abstract

Aims: The potential of artificial intelligence tools to revolutionize breast screening is immense, offering significant operational and clinical gains. Our study aimed to harness this potential by prospectively evaluating multiple strategies for integrating AI into the UK dual reading screening pathway, assessing the clinical and operational benefits and trade-offs.

Methods: A commercially available AI system was deployed within a breast screening unit in a paired prospective evaluation. All cases underwent standard double reading with arbitration of a third when the readers disagreed. The AI was implemented as an extra reader. Here, cases identified not for recall by humans but were flagged by the AI tool for recall underwent an additional human arbitration read with a recall of women needing further evaluation. Other workflow variations were modelled with the live workflow with different objectives: 1) workload reduction, 2) enhanced cancer detection, and 3) decreased recall rates. Performance was measured using recall rate, cancer detection rate, sensitivity, specificity, and positive predictive value. This prospective study was acquired using an opt-out approach.

Results: The evaluation, which included 10,889 women, not including 93 women who opted out, demonstrated the success of the AI implementation. The combination AI workflow significantly improved cancer detection (+10.4%), maintained the recall rate (-0.8%) and enabled up to 31% workload savings. These results provide strong evidence of the potential of AI in breast screening, offering both clinical and operational gains and allowing for adaptation to local healthcare needs.

Discussion: Our study has evaluated several AI implementation strategies that optimize workload savings, CDR, or false positive reduction while improving or not compromising other outcomes. The variety of these strategies underscores the flexibility of AI in breast screening, as they could deliver clinical and operational benefits with a range of trade-offs that can accommodate local requirements.

Conclusion: The findings of our study underscore the potential of AI in breast screening. Multiple AI implementation strategies have been shown to produce clinical and operational benefits in tandem, which could accommodate differing local clinical requirements. This paves the way for a future where AI plays a significant role in improving breast screening outcomes.

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Efficient Signal Processing Techniques and ML Algorithms for Accurate Non-Invasive Blood Glucose Monitoring

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Abstract

Abstract:

Millions of People around the world are suffering from Diabetes Mellitus (Fig. 1).

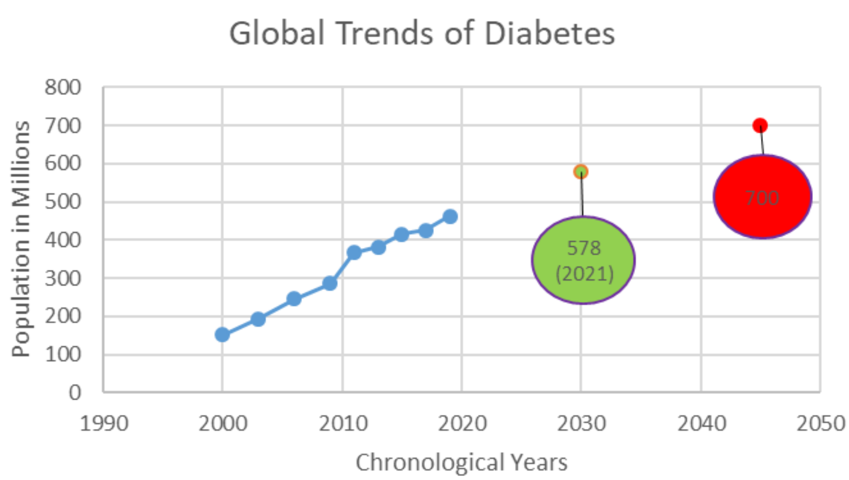

Fig. 1: Global trend of Diabetes, Adopted from [1].

For Diabetic management, patients need to check their Blood Glucose Level (BGL) regularly; people usually avoid the traditional finger pricking method for glucose determination as it causes pain and much discomfort. Many researchers around the world are continuously trying to develop non-invasive blood glucose monitoring (NIBGM) devices, but accuracy is the major challenge that leads to the lack of availability [2]. The main aim of this research work was to implement efficient signal processing techniques and robust Machine Learning (ML) Algorithms for improving the accuracy of NIBGM systems. Fig. 2 shows the complete methodology. Publicly available two Photoplethysmography (PPG) Datasets were used for this research work. Scaling, Filtration (for reducing noise), and Normalization (for further refining the PPG signal) were performed during the Preprocessing stage, and sixteen features were extracted and used for training of classifiers (SVM, KNN, Decision Tree, Logistic Regression, Perceptron) and Regressors (Linear Regressor, SVR, XGBoost, and Gaussian Naive Bayes). The performance of the model was evaluated by metrics such as testing accuracy, precision, recall, F1 Score, and Mean Absolute Error. Our all Models performed very well by achieving a testing accuracy of more than 80%. SVM proved more efficient for classification with testing accuracy, K fold cross validation, Precision, Recall, and F1 score of 87.39%, 87%, 88%, 87%, and 87% respectively. While a minimum mean absolute error of 2mg/dl was obtained by implementing Gaussian Naïve Bayes and Linear Regressors. We can conclude from this study that BGL of any individual can be estimated accurately by using publicly available datasets having a limited number of samples with the implementation of sophisticated signal processing techniques and robust ML Models.

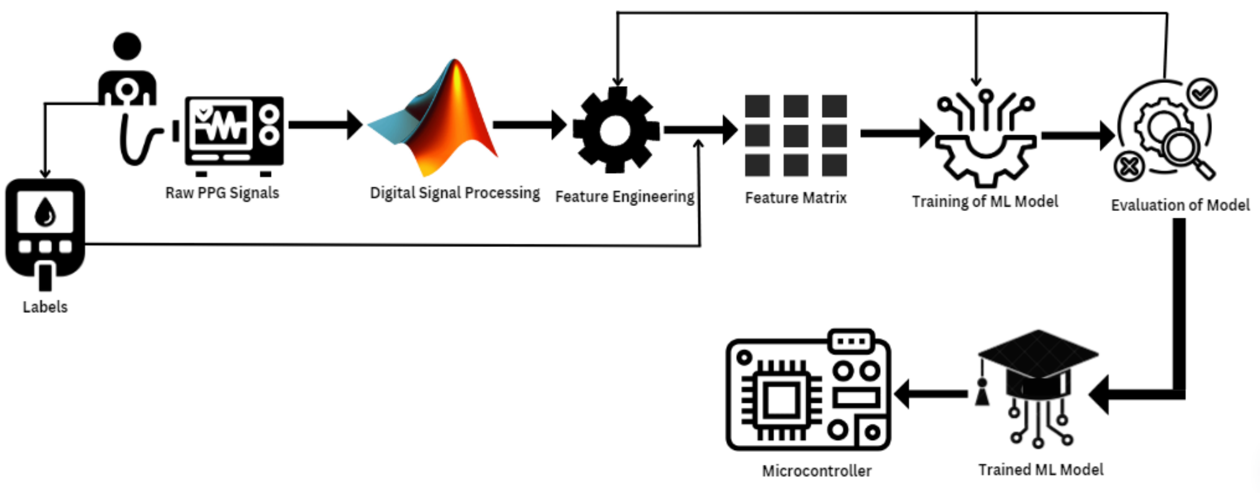

Fig. 2: Overview of this research work

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Clinical Commissioning of a commercial CT Artefact Reduction Algorithm (iMar) for Hip Implants Radiotherapy Planning

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Abstract

Background: The presence of artifacts in the CT images of the pelvis due to the hip prosthesis significantly impacts the accuracy of PTVs and OAR contouring, as well as the dose calculation. Siemens SOMATOM has developed an iterative metal artifact reduction (iMAR) software to enhance image quality by minimizing these artifacts. This study aims to implement the hip iMAR algorithm by comparing the HU values of reference CT images with no metal inserts (no iMAR) with 1 and 2 metal insert CT images (with iMAR).

Material and methods: In this investigation, the AED phantom (Sun Nuclear) was employed with 16 different inserts. The phantom without any metal insert served as the reference for comparison of Hounsfield Units (HU). For the single hip prosthesis effect, only one metal insert was utilized. Two opposite metal inserts were inserted into the phantom to simulate a bilateral hip prosthesis. These three phantom configurations were scanned using five different protocols and reconstructed twice, with and without iMAR. To measure and compare the HU value, 16 different ROIs were meticulously created and consistently registered across all CT images.

Initially, we assessed the impact of iMAR in the absence of any metal insert by calculating the HU differences between reconstructions with and without iMAR for the reference CT images. Subsequently, we gauged the improvement of HU values from the hip iMAR algorithm by computing the absolute HU difference between the reference CT images (no iMAR) and the CT images with 1 and 2 metal inserts (with iMAR) respectively.

Furthermore, we evaluated the clinical goals of 5 patients, all with hip prostheses, before and after implementing the iMAR algorithm, and calculated the absolute differences.

Results: This study demonstrates that the Hounsfield Unit (HU) values for different densities exhibit minimal change (±3HU, less than 1% change in dose calculation) after applying the hip iMAR algorithm in a phantom without metal inserts.

Furthermore, the HU values after iMAR correction of CT images with two metal inserts do not differ by more than ±10 HU compared to the reference images. The differences in HU values are even smaller (±5 HU) between the CT images with one metal insert and the reference images.

Lastly, the comparison of clinical goals between CT images with and without iMAR for double hip prosthesis shows differences up to 0.6%, all within dose limits. For single hip prostheses, these changes are less than 0.1%.

Conclusions: The iMAR algorithm can be used for all patients with hip prostheses. iMAR-corrected images improve organ outline visualization and reduce contouring uncertainties. Furthermore, iMAR images serve as a more reliable reference for CBCT registration.

Key Words: Artifact, iMAR algorithm, Hounsfield Unit (HU) Hip Implant,

27

‘Back to Basics’ Patient Safety Staff Virtual Reality Training

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Abstract

Background: “First, do no harm” is a fundamental principle of healthcare. Analysis of incidents for the Royal United Hospitals Bath NHS Foundation Trusts Patient Safety Incident Response Framework identified top contributors to harm, resulting in creation of five patient safety priorities for improvement work. The ‘Back to Basics’ Patient Safety campaign (B2B) was developed to support these priorities, focusing on simple actions for all staff (Fig.1).

Early identification of deteriorating patient	“Be curious”
Prevent Infection	*“Wash your hands”*
Prevent medication errors	*“Scan the barcode”*
Prevent falls	*“Get patients out of bed”*
Safe discharge	*“Check cannulas removed”*

Fig.1: ‘Back to Basics’ patient safety campaign: What can I do?

Funding gained from Health Education England’s Southwest Simulation Network enabled utilisation of immersive technology to support B2B training (£30k, 12m project). The aim was to produce four 360 degree films that would convey the feeling of working on a busy ward whilst providing refreshingly different, memorable, thought-provoking training accessible to all staff.

Methods: Based upon real incidents, scripts depicting four intertwined fictional patient stories were developed that highlighted priorities of B2B and the repercussions of adverse incidents on patients, families and staff. Backstories were developed for each character and stakeholder involvement from multiple staff groups and clinical leads utilised. With a cast of volunteer staff actors and actresses, ward filming was completed over a weekend using five synchronised 360 degree cameras. Following substantial post processing of audio and video, content was imported into virtual tour software [1] in order to create immersive experiences viewable with VR headsets, computers, tablets and smartphones (Fig.2).

Fig.2: VR headset view when completing training

Staff can virtually sit at a patients' bed or move between ward locations to observe how preventable patient safety incident can arise. Training has been promoted and rolled out across the Trust using promotional trailers, drop-in sessions, tea trolley rounds and online bookings for in-person training. B2B training is available externally at https://RUHBackToBasics.org.uk (Fig.3).

Immersive training: https://RUHBackToBasics.org.uk

Trailer:

Visit from device with gyroscopic sensor and optional Google Cardboard ™ for more immersive experience.

Fig.3: External links to B2B immersive patient safety staff training and promotional trailer

Results: Between January–July 2024, 250 staff have completed virtual reality training with feedback obtained via a QR code accessible electronic form. Positive findings have been measured in staff experience and knowledge of learning objectives (Fig.4). Qualitative data suggests re-experiencing the same scenario from different perspectives aids learning.

Staff Experience	Number of staff trained	250
	Would recommend training to others	98%
	More memorable than conventional e-learning	99%
	Navigation okay / easy / very easy	97%
Staff knowledge of key learning objectives	Safe discharge	94%
	Medication safety	92%
	Hand and equipment washing	100%
	Escalation criteria and urine output accuracy	100%

Fig.4: Results of B2B immersive patient safety staff training questionnaire

Discussion: A National School of Healthcare Science (NSHCS) Innovation Fellowship supported development of immersive technology in healthcare capabilities that enabled this work. Staff feedback has been positive and the use of immersive technology accessible via multiple hardware platforms may bring benefits over other forms of training.

Conclusion:

- The B2B multidisciplinary team have collaborated with multiple staff groups to develop immersive technology training that can be shared externally at scale.
- The immersive technology element of B2B was initiated by NSHCS innovation support.

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Metrology for Radiotherapy at NPL

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Abstract

Background

The safe delivery of dose in Radiotherapy relies on the accurate calibration of the machine and the ability to check this calibration using detectors which are traceable to primary standards such as free air chambers and calorimeters. The National Physical Laboratory has provided such standards and supported traceable calibration through codes of practice [1,2] and calibration services for almost 100 years. In the last 15 years the NPL has expanded their capabilities to a wide range of activity including audits, advanced dosimetry and development of novel detectors.

Methods

Modern radiotherapy has evolved to include a large number of processes which can be susceptible to many uncertainties. NPL have developed a wide range of advanced dosimetry and end-to-end dosimetry audits [3] to assess and reduce these uncertainties, providing all UK RT centres with the data to benchmark their systems against other centres delivering the same techniques with the same or different equipment. To do this NPL has state-of-the-art facilities providing scanning, planning and delivery technologies, including CT scanners, treatment planning systems, a record and verify system and two clinical linacs.

Results

NPL has developed independent dosimetry and validation for the most up to date and emerging radiotherapy techniques including SABR, SRS, FLASH, proton, carbon ion treatments. This requires expertise in TPS, Monte Carlo calculations, independent 2D and 3D dose distribution assessment, new phantom materials for different modalities and designs, novel detectors and the physical dosimetry from macro to microscopic scales. In addition, the group has significant research activity, which includes PhDs and post docs. This has also led to the development of training courses and activities.

Conclusions

The role of NPL is to maintain and develop primary standards and to provide traceability through to the end user. For radiotherapy centres this is achieved by supporting the development of Codes of Practice, traceable dosimetry, independent validation techniques and training, for the current state of the art

techniques and to anticipate future technologies developing dosimetry for these in timely fashion to support implementation into the clinic.

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Metrology for Nuclear Medicine at NPL

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Abstract

Background

Nuclear medicine covers a wide range of diagnostic and therapeutic procedures applied to multiple disease modalities. Increasingly the results of these procedures are being considered as a quantitative measurement, with accompanying legislative and regulatory requirements for uncertainty estimates and traceability to appropriate national standards for all clinical measurements. Since the provision of the UK's first radioactivity standard 114 years ago the UK National Physical Laboratory (NPL) has provided traceability to the Becquerel (Bq) that underpins all clinical uses of radionuclides. The NPL hospital calibration service now provides traceability for activity measurements of common clinical radionuclides to over 90% of UK hospitals and to clinical sites in the EU and radiopharmaceutical manufacturers.

Methods

Clinical nuclear medicine imaging in the form of SPECT (Single Photon Emission Computed Tomography) and PET (Position Emission Tomography) combined with X-ray CT are now commonly used as quantitative measurements. Establishing traceability for these measurands requires the development of uncertainty budgets and calibration procedures. To support these requirements NPL have developed unique capability amongst national measurement institutes with the establishment of a nuclear medicine imaging laboratory [1,2]. This world-leading facility facilitates research in quantitative imaging metrology and provides support for clinical and academic institutes.

Results

An overview of uncertainty assessment in nuclear medicine measurements will be presented, highlighting the importance of establishing measurement traceability to national standards in clinical nuclear medicine. The specific requirements for traceability in quantitative SPECT/CT imaging will be discussed and novel results for establishing full uncertainty budgets for clinical SPECT/CT will be presented.

Conclusions

Uncertainty quantification in nuclear medicine is now a key requirement of accreditation for nuclear medicine, requiring uncertainty budgets and policies for all measurements performed in the clinic [3].

Establishing this accreditation at a national scale requires collaboration between metrology institute and clinical sites to establish best practice guidance and to define appropriate standards. With the increasing awareness of the need for uncertainty quantification in deep learning output [4] from medical imaging (including nuclear medicine imaging) the requirement for rigorous assessment of the uncertainty of input measurands is of increasing importance.

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Metrology for MRI at NPL

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Abstract

Background

MRI is a powerful method for imaging soft tissues non-invasively without the need for ionising radiation. MRI is capable of form many different kinds of images, each containing different types of information. In many cases this means making measurements of tissue properties. These quantitative techniques have the potential to provide consistent and reliable information across different scanners, sites, and timepoints but as yet metrology for these techniques is in its infancy [1].

Methods

Quantitative MRI can measure quantities such as magnetisation decay constants (e.g. T1, T2, T2*), dynamical quantities such as diffusion and flow, and chemical content (e.g. fat fraction), and also spatially extended quantities such as cortical volume. In each case these are measurements of a physical property and as such have associated uncertainties and there is a need for robust calibration and reference materials. Without this, reproducibility is limited but with this we have a framework for supporting the clinical deployment of quantitative methods as well as support for QA regimes for the clinical day to day.

Results

NPL recently led a European consortium aimed at developing metrology to support MRI, and the methods developed are currently being implemented in a new NMR spectrometer facility on-site in Teddington dedicated to MRI metrology. Currently, only NIST offer services in this area and capacity is severely stretched, and limited to a small number of measurands. Work is ongoing at NPL to offer measurement services to both clinical sites and phantom manufacturers, as well as on methods to scale current capabilities to be able to support current and future capacity needs.

Conclusions

The role of NPL is to provide traceability to the SI system in clinically relevant MRI biomarkers, and also to provide guidance and training on metrology for MRI and its day-to-day application both in routine clinical application and for larger studies like clinical trials. We work closely with IPEM, ISMRM, phantom manufacturers, and scanner manufacturers to provide a robust foundation for MRI-based measurement and its role in supporting improved patient outcomes.

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Metrology for Microdosimetry at NPL

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Abstract

Background.

Microdosimetry can assess radiation quality from a biological perspective by quantifying the stochastic nature of energy deposition at microscopic levels, which is critical for understanding and predicting radiobiological effects. Recent technological advancements have provided new tools and approaches for performing microdosimetric measurements in clinically relevant settings necessitating the standardization of these techniques to ensure consistency and reliability across different methods and clinical practice.

Methods.

Utilizing diamond microdosimeters of different thicknesses (1 - 20 µm), we performed measurements at different depths (entrance, peak, fall-off and distal positions) along both proton and carbon ion beams. The experiments were designed to evaluate the detectors' sensitivity and resolution response in clinically relevant conditions. Measurements were supported by Monte Carlo (Geant4) simulations to assess the influence of detector cross sections on the microdosimetric means and other key parameters, such as the mean path length. Additionally, we investigated the use of Look Up Tables (LUT) for integrating the microdosimetric data into treatment planning systems (TPSs).

Results.

Measurements demonstrated the feasibility of performing microdosimetry measurements with diamond detectors at clinically relevant dose rates with acceptable level of signal pile up. Although differences were observed in the microdosimetric spectra, the frequency- and dose-average lineal energy means were consistent for the investigated detector thicknesses at all positions along the Bragg peak. Thinner detectors offered higher spatial resolution but with increased statistical uncertainty. The high lineal energy threshold prevented from capturing contribution from very energetic proton particles in the entrance region and lighter secondary fragments from carbon beams in the distal region. Monte Carlo simulations revealed that decreasing the detector cross section results in a decrease (up to 20%) of the microdosimetric means due to higher fraction of escaping secondary electrons. Moreover, for non-spherical sensitive volumes, the use of the Cauchy formula to estimate the mean chord length is inadequate. A mean path length scored via Monte Carlo represents the ideal solution, although a mean path length equal to the detector thickness is a good approximation. The LUT approach was compatible with RayStation treatment planning system requiring only kinetic energy information to predict

microdosimetric means. Comparison with full Monte Carlo simulations agreed within 1 keV/µm for all depth positions.

Conclusions.

This work sets the foundation for standardized microdosimetric measurements using diamond microdosimeters. By providing combined, detailed and precise dosimetric information at the macro- and micro-scopic level, these advancements enable the development and validation of radiobiological models that can predict effects from cellular to tissue levels. Utilizing patient-specific microdosimetric data into TPS allows for the design of personalized treatment plans that maximize therapeutic efficacy and minimize adverse effects. This approach not only enhances the precision of treatment but also paves the way for integrating radiobiological predictions into clinical practice.

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Metrology for Medical Ultrasound at NPL

Srinath Rajagopal, Andre Alvarenga, Chris Fury, Dan Sarno, Hasan Koruk, Joshua Cole, Nicole Anstey, Raphaela Baesso, Rob Patterson, Swarnim Rai

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Abstract

Background

Diagnostic ultrasound imaging is the second most frequently used imaging modality worldwide after conventional radiography. Though ultrasound is nonionizing, there is potential for tissue damage (thermal and mechanical) during imaging under certain excitation conditions. The therapeutic use of ultrasound has also grown significantly over the last 20 years. The accurate quantification of ultrasound fields to a traceable calibration standard is crucial to ensuring patient safety and treatment efficacy in different applications. NPL has over the years developed and disseminated traceable measurement standards to the worldwide community, built capability for other national measurement institutes, and developed novel ultrasound detection techniques.

Methods

The acoustic pressure measured in pascal [Pa] and the acoustic power in watts [W] are the two main directly traceable parameters required to estimate safety indices, which are regulated through international consensus in collaboration with national measurement institutes, regulatory agencies, and standardisation bodies. NPL has developed word leading capability to disseminate traceability of acoustic pressure in pascal and power in watts. Hydrophones are devices that respond electrically to incident ultrasound. The conversion of electrical signal output of the hydrophone to incident pressure signal requires knowing its calibration response. The primary calibration of the hydrophone is measured on an optical interferometer setup. Equipment manufacturers use these calibrated devices to quantity the acoustic output of their ultrasound systems and assess safety indices. Similarly, there are measurement standards to determine the total output power from ultrasound devices.

Results

Example results from NPL measurement standards for acoustic pascal and power will be presented. The application of hydrophone calibration data and acoustic power data from ultrasound equipment in determining safety indices will be shown. In addition, the group has a significant research activity that led to the development of novel sensors for medical purposes, and their applications will be presented.

Conclusions

NPL has been in the forerunner of researching improved measurement and calibration methods able to address new measurement challenges provided by emerging medical ultrasound equipment. NPL's research helps manufacturers develop new products and provides the healthcare user community with the confidence that diagnostic and therapeutic systems are safe and effective.

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Metrology for Data Science in Medical Physics at NPL

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Abstract

Background

In the current digital age, data from measurements are routinely collected for a wide range of applications. In addition, recent advances in AI for healthcare present new challenges for measurement science and the metrology community. Standardised digital records enable meta-analysis of the data which may reveal unknown patterns, clusters or correlations improving our understanding of the measurements and their application domains. A metrological approach is critical in complex areas such as in healthcare, and in particular in those areas related to clinical decision making.

Methods

NPL applies metrological data science techniques to healthcare data, including standardisation of AI techniques applied to medical imaging to detect cancers, meta-analysis which may reveal unknown patterns, clusters or correlations improving our understanding of the measurements and their application domains, and predictive modelling to understand impact factors for diseases such as dementia. We also use data-driven machine learning and feature importance techniques to search for hidden patterns within linked radiotherapy datasets.

Results

NPL has developed a digitally enabled measurement infrastructure to support clinically relevant research. An exemplar project uses dosimetry audit data for advanced radiotherapy, storing healthcare-type data and showing the benefits of a structured, linked, FAIR (findable, accessible, interoperable, reproducible) approach to data capture and storage.

NPL has also helped lead the development and implementation of a standardised and impartial framework for performance, generalisability, and suitability assessment of image-based AI systems for disease detection, risk prediction and decision making. Breast cancer screening is used as an exemplar, using a large-scale database of mammography images.

NPL leads work using quality assurance and calibration data from MRI scanners to improve the comparability of medical images and the development of specialised phantoms for use in quantitative MRI to support clinical imaging standardisation across different machines. This has resulted in a suite of

training courses for clinical MRI physicists, including material on uncertainty evaluation developed with clinicians as a target audience.

Discussion and conclusions

Providing confidence in the intelligent and effective use of data is at the heart of NPL Data Science. NPL provides reference data sets as exemplars of well-curated data with defined quality metrics; validated models and methods, with uncertainty quantification; standards to capture important clinical data and metadata; and metrology training to clinical professionals.

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Developing a Practical Local Framework for Responsible AI Deployment

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Abstract

Many frameworks for AI tool development and deployment have been published, however there was a need for a practical local solution giving specific guidance on AI tool deployment within the Sheffield Teaching Hospitals NHS FT Medical Imaging and Medical Physics directorate. This framework guides the user through who they need to contact, what information they need to provide and discussions to have, and what steps they need to take in order to successfully clinically deploy an AI tool.

The framework was developed through a literature review, discussions with stakeholders including the IT, PACS, Information Governance, Clinical Effectiveness teams and by working closely with a group of AI Experts within the directorate. Other stakeholders including a group of possible users and a patient and public involvement group provided feedback on the draft framework.

The framework consists of 5 stages. Stage 1 includes a screener questionnaire to be reviewed by the local AI Expert Group to advise the user on whether there are any initial concerns about the tool. Stage 2 gives guidance on how to perform and evaluate validation tests, including assessment of tool usability, stakeholder engagement, and information governance. Stage 3 concerns clinical deployment, giving guidance on training and recommending a pilot roll-out before full clinical deployment. Stage 4 provides guidance on maintenance of the AI tool, including validation of updates to the algorithm. Finally stage 5 includes information on decommissioning the AI tool and cancelling the deployment project if the tool does not perform as well as required. Throughout the framework, the user will be provided with advice and support from the AI Expert Group.

By following the framework, the user will establish early whether the tool does not meet the requirements for clinical deployment. Therefore only tools that have been proven to work effectively and have satisfactory accuracy within the local setting, will be deployed to the clinical environment. This will also ensure that AI tools proven to work well in initial tests will follow a process that enables responsible and successful clinical deployment.

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Developing a sustainable clinical scientist and technologist workforce in rehabilitation engineering to optimize service delivery – a case study

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Abstract

BACKGROUND

SMART Services provide 11 clinical rehabilitation technology services that mostly cover the Southeast region of Scotland, serving a population of around 1.4 million. It employs around 116 WTE staff of which 16 WTE are healthcare scientists deployed in two teams. The department has evolved gradually to meet changing clinical needs and to take advantage of increasing technological potential, boosted by mergers with other related rehabilitation technology based services.

Several factors have impacted the workforce over the past 25 years. These include the requirement for professional registration impacting the training requirements for the 'bioengineers' and the narrow age-cohort of the 'technicians' approaching retirement, as well as Agenda for Change removing role differentials. It became increasingly difficult to recruit staff with the required qualifications and skills. It was therefore necessary to reconsider the structure, skill mix and roles within the two teams with the dual objectives of supporting staff development and progression and ensuring safe and resilient service provision with succession planning. The overarching aim being to optimise service performance to meet demand and achieve local and national targets.

METHODS

The workforce and skill mix of the scientific and technologist teams were reviewed in cooperation with staff and their representatives and new roles and structures were developed and implemented following formal approval via established organisational change processes.

RESULTS

The scientific team has changed from a team consisting of 3 Principal and 3 Senior Clinical Scientists to one consisting of a Head of Assistive Technology, 2 Leads, 3 Senior and 1 Healthcare Science Practitioner (HCSP). Three of the four HSCP post-holders have gone on to formally train as Clinical Scientists within the department under the umbrella of the Scottish Medical Physics and Clinical Engineering Training Scheme. Only one post remains vacant and all the Clinical Scientists have qualified whilst in the department. One is registered as a Higher Specialist Scientist and another is about to complete.

The technologist team has changed from a team consisting of a Workshop Manager, 6 Senior Rehabilitation Engineers and 1 Stores Person to one consisting of a manager with 3 Senior, 3 Rehabilitation Engineers and 1 Rehabilitation Technician with 1.5 Stores & Procurement Officers.

Staff now work across services, ensuring cover when there are unplanned absences, as well as improved flexibility and overall resilience. Vacancy and turnover rates have reduced and overall service performance has improved.

CONCLUSION

Restructuring staffing teams and roles is a medium to long-term investment that has led to a more sustainable, flexible and resilient home grown workforce capable of providing better and safer clinical services.

KEYWORDS

Rehabilitation Engineering, Workforce, Skills, Clinical Scientists, Clinical Technologists

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Rebuilding a Clinical Engineering Department

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Abstract

Background

New appointments to the Leadership of Clinical Engineering at the Royal Berkshire NHS Foundation Trust in 2020, triggered an appraisal of the service. This indicated that Clinical Engineering would not meet basic expected Performance. A strategy was constructed to address the gap between the current position and the expectation.

Method

We used the following ten questions to guide our assessment:

1. Are requests for support being responded to adequately?
2. Is Planned Maintenance effective and up to date?
3. Are new devices being accepted and commissioned correctly?
4. Are devices being decommissioned and disposed of correctly?
5. Is medical Devices User Training effective and properly managed?
6. Is the inventory data reliable?
7. Is Medical Devices Safety meeting requirements?
8. Are the members of the team receiving effective management?
9. Do clinical teams feel supported?
10. Are the working spaces adequate?

Although not a full assessment, it was felt that these measures would be helpful in understanding the current position and inform a gap analysis.

Results

1. There was a slow response to support requests, poor record keeping and long waits.
2. It was almost impossible to assess the Planned Maintenance compliance due to poor data quality
3. Acceptance and commissioning was inconsistent, informal and record keeping was poor
4. Decommissioning and disposal was inconsistent and record keeping was poor
5. User training compliance was impossible to assess
6. Inventory data was inconsistent and unreliable

7. There was no information on Medical Device Alerts compliance and Incident report response
8. Team management was inconsistent. Some had not had an appraisal in over five years.
9. Some clinical teams responded positively to a simple questionnaire, but others were unable to respond or unsure of whether they were being supported
10. Working spaces were poorly maintained, cluttered and poorly managed

Discussion

It was clear that there was no scope to meet high quality KPIs at this stage, so some practical objectives were agreed regarding People and Spaces.

1. Submit a business case for additional posts and reconfiguration of the current staff structure
2. Improve working spaces
3. Improve management practices

A strategy meeting in 2021 resulted in the following objectives:

1. A measurable improvement in completing reactive jobs within four working weeks.
2. Formally agreed processes and procedures and begin to build a Quality Management System
3. Deliver on the agreed staffing business case
4. Improve communication internally and externally

Conclusion

Although complicated by the Covid pandemic, there has been considerable success in rebuilding CE.

- The structure reconfiguration was completed in mid-2023.
- Now able to measure and respond to KPIs
- Achieving almost 80% PPM compliance for high risk devices
- Over 75% compliance for medical devices training
- Excellent NHS Staff Survey results

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The Success of the Clinical Engineering Internship Programme at the Royal Berkshire Foundation Trust

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Abstract

Background

Over the last four years the Clinical Engineering (CE) Department at the Royal Berkshire NHS Foundation Trust has struggled to recruit and retain experienced Clinical Engineers/Technologists. Fierce competition and high local cost of living have been major factors. To encourage recruitment into CE, the Department has partnered with the University of Reading (UoR) to establish a 1-year, paid rolling internship programme. A key aim is to provide an opportunity for students to apply their theoretical knowledge to real world situations whilst learning about all aspects of CE.

Methodology

UoR students who have successfully completed their 2nd year undergraduate course in Bioengineering are eligible to apply. The selection process is via application and interview panel. Successful applicants are employed on a 1-year contract. Through a structured and supervised programme of hands-on learning and practical experience (Figure 1) the Interns will gain insight into the various roles and tasks of a CE Department.

Figure 1: Internship rotation 2024/25

	Intern (Name)	Supervisor
Induction & Handover	**Dates (weeks) - 2024**	Deputy Head
Corporate Induction		CEO/Induction Team
Mandatory Training & Handover		Deputy Head
Introduction to Clinical Engineering processes & procedures & developing skills in the Workshop • Medical Devices Inventory (e-Quip) • Quality Management • Front Desk • Stock Control Management • Equipment Cleaning & Decontamination • Electrical Safety Test • Planned Preventative Maintenance (low-medium, high risk devices) • Infusion Pump Training • Supporting Audit		Deputy Head / Specialist Managers
Shadowing	**Dates (weeks) - 2024**	
• Medical Devices Safety Notices		Deputy Head / MDSO
• Contracts Management		Contracts Manager
• Medical Devices Clinical User Training		Medical Devices Training Coordinator
• Projects Team		Projects Manager
Workshops (PPM / RM)		
Battle Block & Eye Clinic • Cardiology • Elderly • Stroke Unit		Band 6
Eye Block Ophthalmology		Band 6
Centre Block Radiology ED Respiratory Acute Medical Unit /Short Stay Unit/HMU		Band 6
South Block Anaesthetics Team Theatres / Recovery / ICU		Anaesthetics Band 6 Theatres/ICU Band 6
Maternity, Neonatal & Paediatrics Teams		Band 6
Device Integration		Bands 6 & 7
Equipment Library Mattress / Infusion Pump Libraries		Band 5
Renal Team		Band 7
Handover to in-coming interns / Completing Reports/ Presentation		Deputy Head
Clinical area visits		
Cardiology		Area Clinical Specialist
Respiratory		Area Clinical Specialist
Radiology (MRI/CT/X-ray)		Med Phys Technical Specialist
Radiotherapy Physics		Med Phys Technical Specialist
Medical Physics		Med Phys Technical Specialist
Radiation Protection		Med Phys Technical Specialists (non-ionising & ionising)

Results

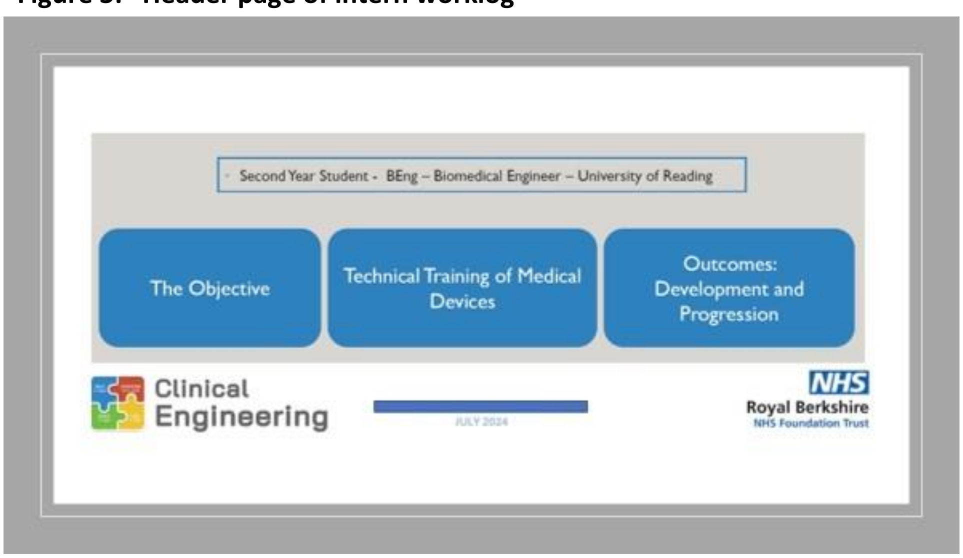
The success of the programme can be demonstrated by each Intern being able to carry out planned and reactive maintenance on all types of medical devices as well as, development of their soft skills (Figure

2). Moreover, we have seen an increase in the numbers of applications each year ie. N=3 (2020) versus N=12 (2024) which has led to additional funding to sponsor N=2 interns each year.

Figure 2: Soft-skill development

Each Intern produced a portfolio detailing their learning and work experience as evidence of their internship (Figure 3).

Figure 3: Header page of intern worklog



Feedback from the Interns has been very positive and encouraging for the future of CE. At the start of their internship none had any prior knowledge/experience of CE but by the end of their year, most were strongly considering a career as a Clinical Engineer (Table 1).

Table 1: Internship Overview

Year of Internship	No. Interns	Where are they now?
2020 - 2021	1	Successful application to STP; completing final year
2021 - 2022	1	Band 4/5 CE Technologist, Royal Berkshire Hospital
2022 - 2023	1	Final year of Masters in Bioengineering, UoR
2023 - 2024	2	Returning to UoR to complete undergraduate Bioengineering degree; one intern wants to become a Project Manager in CE, second intern is considering a career in the military with the Defence Medical Services
2024 - 2025	2	2 x new interns started July 2024

Discussion & Conclusion

Clinical Engineers/Technologists play a critical role in patient health and wellbeing through medical equipment lifecycle management. Prolonged challenges to recruitment, retention and losses from pending retirements will further result in a reduced workforce. Our Internship programme has shown, giving young people the opportunity to explore and gain practical experience of the work of the Clinical Engineer through a structured curriculum provides one solution to secure the future of the Profession and the NHS.

Key words: Clinical Engineering, Technologist, Internship Programme, Medical Devices, EBME

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We need to fix the basics; exploring the experiences of disabled patients and staff in the NHS.

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Abstract

Despite being the "world's largest minority", there is a significant gap in the experiences and outcomes of disabled patients and disabled staff in the healthcare system. Addressing long standing health inequities is crucial in improving outcomes, especially when intersectionality is considered. This is even more important given the rapid pace of innovation, which may risk further embedding inequities or simply distracting from problems that already exist.

It is also important to consider both patients and staff, as there is not a clear divide between 'disabled people who use health services' and 'health staff who are not disabled'. Disabled staff also bring both professional and lived experience, so are an important part of the conversation.

No specific data collection has been performed for this abstract submission, but data from the ONS, Cancer Patient Experience survey, peer reviewed studies and NHS staff survey can be utilised alongside other sources of insight to demonstrate inequities that continue to exist for staff and patients in the NHS. The author is also multiply disabled and neurodivergent, is a carer to disabled family members, and has worked within the NHS so this submission is informed by lived experience.

As an example, the COVID-19 pandemic highlighted some of the huge health inequities that impact disabled and neurodivergent people. 60% of those that died in the first year of the pandemic were disabled. This was not solely due to comorbidities that can make disabled people more vulnerable, but reflected a system that has for a long time placed less value on the lives of disabled people. In the wider health system, disabled people are less likely to report a good experience of cancer care (Cancer Patient Experience Survey), report facing longer waits for care (HealthWatch), and consistently report issues with access and communication.

The NHS has many disabled and neurodivergent staff, but many remain hidden. A similar proportion of staff report a disability in the anonymous NHS staff survey compared to the wider working population, but only 4% of staff have disability recorded on ESR. This may reflect an issue with data quality but is also likely to reflect the fact staff are worried to disclose their disability. Disabled NHS staff are more likely to report experiencing harassment and bullying and many disabled staff report not being given the legally required reasonable adjustments that would enable them to do their job.

These examples reflect a system that places a lower value on the lives and wellbeing of those with disabilities and neurodivergence. There is a consistent gap in experience and outcomes, which will not be closed without meaningfully listening to and examining the experiences of those with disabilities.

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Enhancing Radiotherapy Planning with AI: Implementation of Limbus Contour at Clatterbridge Cancer Centre

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Abstract

Background. This report outlines the implementation of Limbus Contour (Radformation Inc.), an AI-based auto-contouring software, at Clatterbridge Cancer Centre to assist in contouring organs at risk for radiotherapy patients. Using pre-trained machine learning models, the software automatically delineates organs based on CT or MRI images, aiming to enhance efficiency and accuracy in the contouring process. Integrating Limbus Contour into the clinical workflow can potentially save time and improve contour consistency compared to manual methods.

Methods.

A new clinical workflow was established:

- Automated export of planning images from the CT/MRI scanner directly to Limbus
- Auto-contouring of specific organs using structure templates based on specific DICOM tags of the planning images
- Automated import of contoured DICOM RT-Structure files into the treatment planning system
- Review and adjustment of contours by trained professional (Advanced Dosimetry Practitioner)
- Review and adjustment of contours by clinicians

The new workflow testing included:

- Checking data export/import functionality
- Ensuring correct structure templates are used for the correct anatomy
- Evaluating the quality of generated contours by comparing Limbus contours with those from previous auto-contouring software across various anatomical sites, verified by Dosimetry Advanced Practitioner.

The commissioning process also involved risk assessment, implementation of regular quality assurance and management of regular upgrades. Clinical implementation of Limbus Contour was followed up with an audit after the first seven days of clinical use.

Results. Testing confirmed efficient export/import of planning scans and structure sets to the treatment planning system, with correct application of structure templates to various anatomical sites. Quality evaluations showed that Limbus contours were generally comparable to those from previous software

(based on qualitative assessment). Dosimetry Advanced Practitioner found that contours were generally acceptable, with some adjustments needed for specific organs.

Risk assessment identified potential failures in automatic export/import that could delay patient treatment. This was mitigated by allowing manual export/import and contouring when necessary.

Quarterly quality control was introduced to ensure reproducibility and consistency of structures from a reference planning scan. New software versions can be quickly tested using a subset of commissioning scans, and a new reference structure set is established for quality control.

An audit conducted after the first seven days of use revealed no issues with generating correct structure sets for the anatomy and efficiently transferring CT scans and auto-contoured structures to the Eclipse Treatment Planning System. However, users reported several issues: the topogram was being sent to Limbus, the bronchial tree was missing in the Torax/Abdo template, and some structures had incorrect colours.

Discussion. Limbus Contour demonstrated good quality contours and efficiency savings in clinical workflows. Limbus Contour was accepted for clinical use from 18th March 2023.

Key references: N/A

Key words: auto-contouring, organs at risk, efficiency

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Development of a Specialised Radiation Shielding Calculator for Diverse X-Ray Modalities

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Abstract

Background: Ensuring radiation safety in clinical X-ray imaging is crucial. Advances in X-ray technology necessitate revisiting current radiation shielding methodologies, especially in clinical settings with diverse imaging modalities, requiring adaptable and comprehensive shielding strategies. Effective shielding minimises radiation scatter and intensity, upholding the ALARA principle in radiation protection (NCRP, 1993). Traditional manual shielding calculations often rely on conservative assumptions, emphasising the need for precise models that accurately reflect operational ranges (Simpkin, 1996a). This project aims to provide a reliable, user-friendly tool that integrates standards from BIR and NCRP, incorporates the latest Irish dose constraints, and significantly reduces the time required for complex shielding calculations (BIR, 2012; NCRP, 2004; EPA, 2022).

Methods: The development began with meticulous planning and creating a detailed flowchart using Lucidchart. The calculator covers General X-ray, fluoroscopy, chest X-ray, R&F, mammography, dental, DXA, and CT modalities. It integrates the latest BIR and NCRP guidelines for accuracy. A user-friendly GUI was developed using PyQt5, and Python was chosen for its simplicity and extensive libraries. Data management involved integrating CSV files with fitting parameters for primary and scatter radiation (35-140kVp) and occupancy factors. Strategic methods addressed data linkage issues and missing factors, considering nearby areas. Equation simplification was focused on enhancing efficiency without compromising accuracy.

Results: Validation against BIR and NCRP sample calculations showed nearly identical results, with minor discrepancies in secondary fitting parameters over 100kVp. The refined GUI ensures a seamless user experience. Standalone applications for Windows and macOS significantly reduce the time required for complex radiation shielding calculations, enhancing versatility.

Discussion: This calculator addresses gaps in current tools, including human errors, resource commitments, and lack of comprehensive solutions. Its versatility allows cross-checking shielding with BIR and NCRP methods, reducing error risk and providing flexibility. By automating and simplifying processes, it enhances efficiency in clinical settings.

Conclusion: This specialised calculator improves the accuracy and usability of shielding calculations, addresses deficiencies in current tools, and allows cross-verification with BIR and NCRP methods. By reducing the time for complex processes, it enhances radiation protection and operational efficiency, offering a robust, user-friendly solution for radiological environments.

Check out a brief video showcasing the calculator in action: https://youtu.be/s0emaZLPtJI

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Optimising Imaging in Radiotherapy: A Mentee's Perspective from the ICRP TG116 Project

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Abstract

Cone Beam CT (CBCT) has increasingly become a crucial imaging tool in radiotherapy, enhancing treatment planning and verification, especially in Image Guided Radiotherapy (IGRT). However, the cumulative dose from frequent CBCT imaging poses a potential risk for patients, necessitating optimisation of imaging protocols. The ICRP Task Group 116 (TG116) aims to optimise radiological protection in imaging for radiotherapy.

Historically, the imaging dose in radiotherapy was considered negligible compared to the therapeutic dose. However, the paradigm has shifted as patients live longer, increasing the risk of secondary cancers from cumulative imaging doses. Additionally, the lack of integration of kV imaging doses in Treatment Planning Systems (TPS) hinders the ability to manage these doses effectively. Surveys show that globally, most radiotherapy centres rely on vendor default protocols without optimising them due to the absence of dose information, especially in medium and low income countries.

The TG116 mentorship project tries to address the challenge of accurately measuring and optimising doses from CBCT systems integrated with linear accelerators. Mentee measurements of dosimetric data involve the use of cylindrical CTDI and slab PMMA/solid water phantoms. Farmer chambers and 100mm CT-chambers are utilised for measurements at central and peripheral positions within the phantoms, testing different exposure factor combinations, of commonly used imaging protocols. Our results indicate that slab phantoms may be eligible to be used instead of cylindrical phantoms, providing consistent and reliable dosimetric measurements. This finding is crucial as it can possibly offer a practical solution for radiotherapy centres with difficult or no access to diagnostic imaging measurement equipment.

Collected data across 16 countries show significant variations in dose delivery based on kV, filter settings and other factors, highlighting the need for optimised imaging protocols. These protocols must balance image quality and radiation dose to ensure patient safety. The next phase of the project involves collecting exposure data on standard imaging protocols, standardising data collection methods, and establishing Dose Reference Levels (DRLs) for CBCT.

The ultimate goal is to extend the project to more radiotherapy centres globally. Mentees, like me, will need to collaborate with colleagues at other institutions in their country, to conduct similar measurements and gather data on imaging protocols. This broader dataset will help create a

comprehensive picture of dose levels from imaging in radiotherapy, and will allow a more accurate comparison between different centres and counties or regions.

In conclusion, the TG116 project is making significant strides in standardising dosimetric practices for CBCT in radiotherapy. My involvement as a mentee has been mostly but not limited in gathering crucial data to inform future protocols and reference values. By expanding our efforts and collaborating with more centres, we aim to improve patient safety and treatment efficacy in radiotherapy locally and globally.

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Clinical Decision Support for Falls Management: A Machine Learning Approach

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Abstract

Background

Falls are a leading cause of injury in older adults, with one in three people aged over 65 falling each year. Unexplained falls (UF) account for 1 in 4 of these falls [1]. Growing evidence suggests that cerebrovascular and cardiovascular factors are important clinically modifiable risk factors for UF [2]. Our goal here was to investigate for the first time the feasibility of combining explainable machine learning (xAI/ML) and novel neurocardiovascular indices of falls risk [2] in identifying patients at risk of unexplained falls (UF).

Methods

Patients attending a national Falls and Syncope Unit with UF and (age, gender) matched controls from The Irish Longitudinal Study on Ageing (TILDA) were recruited [3]. Participants underwent an active stand (AS) test with concurrent monitoring of continuous blood pressure (BP)[4] and cerebral oxygenation tissue saturation index (TSI). To classify between controls and patients with UF, xAI/ML models (linear (LDA) and quadratic discriminant analysis (QDA), support vector machines (SVM)) were developed using features from continuous BP, TSI, and patient medical history. ROC curve-derived parameters (area under the curve (AUC)) were used to assess model performance.

Results

A total of 366 participants were included in this study (183 patients (age 70 IQR(14); 59.6% female), 183 controls (age 70 IQR(13); 54.6% female)). Best performing models resulted from using an LDA with TSI feature data (LDA AUC: 0.70), and a QDA model with SBP features (QDA AUC: 0.779). Combining both TSI and SBP features improved model performance (QDA AUC:

0.812) for UF classification. Inclusion of clinical history improved model performance further for identifying UF (SVM AUC: 0.875).

Conclusion

This study demonstrates that xAI/ML trained on a unique dataset can be used to identify patients with UF and syncope using a combination of TSI, SBP and clinical history. Model differences are suggestive of physiological origins for UF, with UF a possible marker of brain ageing. These models are now being translated into the design of clinical decision support tools to assist patient management.

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The application of computer simulation for Physicist clinical experiential training: experience gained at NPL.

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Abstract

Background

Global challenges, such as access to clinical resources/ experienced mentors and travel restrictions, persist for high quality training. Computer simulation offers practical solutions, providing interactive clinical experiential learning (6), and standardisation across participating institutions (5).

VERT (1) is an established Radiographer training tool, including physics education (4); Physicist training (3) has been explored, noting sophisticated simulations of dosimetric protocols (2) may provide great value. A cloud-based Learning Management system (LMS) broadens accessibility beyond the classroom.

This study's aim was to evaluate its applicability within courses at NPL to indicate wider applicability for Physicist training.

Methods

Detailed simulations of IPEM (1990/2020) CoPs and TRS398/ TRS483/ TG51 calibration protocols have been developed in VERT, providing virtual dosimetry equipment for use with its Linacs. Simulated measurements determine reflect experimental setup, including systematic and random uncertainties. An e-learning module supports the provision of interactive course material and competency assessments which can be saved on completion as evidence.

Results

These modules were used at NPL, during the (2023) ESTRO Practical Dosimetry Audit course and their Practical Course in Reference Dosimetry (2023/ 2024), in group sessions and in conjunction with

practical sessions, to virtually explore simulated error scenarios, impact of uncertainties, equipment management and the faculty's vast experience.

Demonstrations included the 'detector choice uncertainty' in the estimation of very small field factors, which otherwise, due to time constraints would not be accommodated in practical sessions. The impact of the use of wrong field sizes, temperature and pressure variations (amongst others) were explored extensively.

Participant feedback was enthusiastic, and faculty reflected that simulation sessions had broadened the teaching, adding value to training beyond that given by the practical training.

Discussion

We have proposed a pilot study to assess the integration of computer simulation training into STP, a study methodology has been designed and grant funding sought. The pilot builds on the study reported here and similar experience and proposals for international training schemes and is therefore part of our broader research programme.

Conclusion

VERT adds value to existing professional training courses for Radiotherapy Physicist training. The key benefit of computer simulation training is the ability to safely explore 'never-events' and errors/ mistakes. It standardises the training experience and is likely to help expand training schemes where provision of resources and travel prove challenging.

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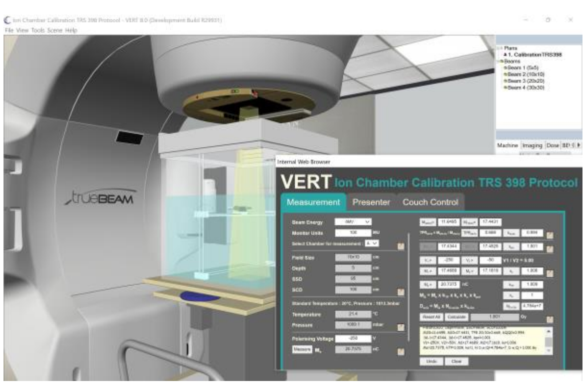

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