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Policy Statement

The Role of Clinical and Scientific Computing in Medical Physics and Clinical Engineering

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Abstract

Clinical and Scientific Computing involves the application of computing related skills to support and enhance the medical services used to manage, diagnose and treat patients. This document describes the potential roles and responsibilities of Healthcare Scientists within Clinical and Scientific Computing, the routes to Clinical Scientist and Consultant Clinical Scientist and what to do if you are interested in such roles.

Intended Audience

This is an introductory document for:

- School students and school leavers with an interest in healthcare and computing.
- University students/post-grad students looking for post-education opportunities in Clinical and Scientific Computing.
- Healthcare Scientists looking to specialise in Clinical and Scientific Computing.
- Managers interested in the skill set of a Clinical and Scientific Computing team.

1. Introduction to Clinical and Scientific Computing in the NHS

Clinical and Scientific Computing involves the application of computing related skills to enable, enhance and support the medical services used to diagnose and treat patients. Similar to all Healthcare Science specialisms, patient care and safety is a key part of Clinical and Scientific Computing. Even though the specialism is not directly patient facing, it does play a vital role in medical device safety, cyber security, and confidential data handling.

2. Roles and responsibilities in Clinical and Scientific Computing

Healthcare Scientists within Clinical and Scientific Computing come from a broad range of backgrounds and may work across multiple disciplines (1). They typically have a science degree with experience in Computing, Engineering, Informatics or Physics and they may have an MSc or PhD in a relevant subject. They may also have clinical training obtained either through a training scheme such as the NHS Scientist Training Program (2) or through equivalent work-based learning and experience. Depending on the Healthcare Scientist's role, training and background they may be registered as a Clinical Technologist (3) or Clinical Scientist (4). There is no defined job title and therefore the roles may be carried out by Healthcare Scientists with a dedicated position (for example as a 'Bioinformatician') or with additional responsibilities to their main role (for example as a 'Medical Physicist').

Depending on the role and experience of the Healthcare Scientist, responsibilities range from following defined processes under direct supervision to being the asset owner for major Clinical and Scientific Computing changes which will affect whole clinical services. Responsibilities may also include developing processes, working independently or in multidisciplinary teams, and training others. Healthcare Scientists must ensure due diligence is carried within their scope of practice to ensure patient safety.

2.1 Software engineering

2.1.1 Software Engineering Role

The need for Healthcare Scientists who can develop and maintain software used within a clinical environment is the leading driving force behind the formation of Clinical and Scientific Computing teams (5). Software engineering includes (but is not limited to):

- Artificial Intelligence and Deep Learning research, implementation and monitoring.
- Modernising and replacing obsolete processes.
- Developing data queries for reporting, audits and bulk data processing.
- Automation of repetitive tasks.
- Developing in-house Medical Device Software, following best practice, for example IPEM best practice guidance (6) and the standards it contains.

2.1.2 Software Engineering Case Study – Quantitative reporting of cerebral blood flow scans for presurgical mapping for epilepsy resection.

Problem: Blood flow in the brain during an epileptic seizure can be visualised using an imaging scanner called single photon emission computed tomography (SPECT) and a radiotracer called Tc^{99m}-HMPAO. The radio tracer is injected into the patient when they are having a seizure and then later, when they are well enough, the SPECT scanner can take pictures of the areas in the brain that the radiotracer ended up during the seizure. This image can be compared to another image of the same patient when they are not having a seizure. The problem is that these differences are quite difficult to see with the unaided eye and it takes years of practice for a radiologist to get good at spotting these subtle differences.

Solution: A computer program was written in Matlab to align all the images from each patient to one another and then subtract one SPECT image from the other in order to be able to use simple statistical tests to display areas of difference associated with seizure activity.
(https://www.frontiersin.org/files/Articles/519751/fneur-11-00467-HTML/image_m/fneur-11-00467-g001.jpg)

Clinical Benefit: This helped the surgeons visualise the areas of the brain that could be resected in order to stop seizures for patients where drug treatment has failed.

2.1.3 Software Engineering Case Study – Integrated scripting environments

Situation: Manufacturers are increasingly including APIs (Application Programming Interfaces) within their products. APIs allow two systems to communicate with each other. In the context of Clinical and Scientific Computing, this generally allows clinical users to develop their own scripts and programs to control the main software. Examples include Python scripting inside a treatment planning system to automate common processes and smart forms inside an Oncology Management Systems.

Solution: As scripting APIs become more common, and the tools become more integral to clinical pathways, the management of these scripts becomes more important. Healthcare Scientists working within Clinical and Scientific Computing may develop, deploy and manage these scripts. They may also provide valuable expertise when these tasks are done outside Clinical and Scientific Computing.

Clinical benefit: The contribution of Healthcare Scientists in Clinical and Scientific Computing within a multidisciplinary team will enable, support and lead the development of complex scripts. These complex scripts will then allow automation, patient pathway optimisation and risk reduction due to manual processes.

2.2 Clinical connectivity and clinical infrastructure

2.2.1 Connectivity and Infrastructure Role

Modern healthcare has a wide variety of specialist equipment that generates proprietary and version specific data. Issues arise when these devices cannot communicate with each other.
Healthcare Scientists manage, maintain and develop solutions for the clinical computing infrastructure and the connectivity between systems and medical devices within a clinical environment. Connectivity and Infrastructure activities include (but are not limited to):

- Developing custom interfaces (as in the Software Engineering Case Study above).
- Management of specialised Health IT systems (e.g. an X-ray image management system).
- Specifying, installing, testing and maintaining computer systems, networks and interfaces.
- Working directly with health IT teams & equipment manufacturers.
- Participating in projects with commercial companies developing and testing early version products.

2.2.2 Connectivity and Infrastructure Case Study – HL7 interface in Radiotherapy
Problem: A hospital has a very large database which exports information in a proprietary format which cannot be imported by newly procured software.
The Radiotherapy Department procured a new Oncology Information System (OIS) which used an HL7 interface to receive patient demographics from external systems. HL7 is the communication standard used to transfer text based messages, for example lab results, between clinical systems. The hospital's Patient Administration System (PAS) (due for replacement 2 - 3 years later) did not support HL7 messaging but could export data into text files. An interim solution was required to allow the two systems to communicate directly, rather than use manual transcription.
Solution: The main hospital health IT team was engaged to provide a feed of text files containing the required patient demographics from the PAS. This file was resent whenever relevant changes were made in the PAS. A piece of middleware was developed to translate the text files received into a specified HL7 message format and to transmit these HL7 file to the OIS interface. The OIS manufacturers interface team were consulted with to ensure that the receiving interface accepted the HL7 messages and that the received information was transferred into the appropriate fields in the OIS database.
Clinical benefit: Clinical staff no longer had to transcribe patient demographic data into the OIS saving both time and reducing the risk of transcription errors. The resending of data when changes occurred on the PAS ensured continued accuracy of the information held by Radiotherapy.

2.3 Data and Security

2.3.1 Data and Security Role
As the demand for "Big Data" within a clinical context increases, Healthcare Scientists who understand the data and security concerns that come with networked hardware and software will be an essential part of the workforce. Clinical and Scientific Computing teams work with ICT and Informatics Departments to ensure patient data is used and stored securely and that networked medical devices balance security and patient safety.
2.3.2 Data and Security Case Study – Clinical-to-research data pipeline
Problem: An NHS Trust has access to a database of thousands of patient's radiotherapy treatment data; however, these could only be accessed one patient at a time. There was no standardised or efficient method for utilising large quantities of this data for research, service development or audit. The process for justifying access was uncertain, deidentification was carried out poorly and extracted data could be easily duplicated in the research analysis.
Solution: A clinical-to-research data access pipeline was set up to allow the approval, cohort identification, data extraction, deidentification, and storage to be standardised. Large cohorts can now be generated and deidentified in a standardised way, ensuring a patient's privacy is preserved while also benefitting from the information it contains. Occasionally, significant findings identified during the data processing need to be fed back to a patient's clinical team. A secure lookup table was also created to allow a patient's clinical team to reidentify them if needed.
Clinical benefit: The pipeline was used to extract data for a clinical audit. Approximately 70,000 files corresponding to 44,000 patients were analysed and 1 file containing a significant finding was found. Using this clinical staff could follow up with the patient to ensure the finding was not harmful (7).

2.4 Risk Management / Quality Assurance

2.4.1 Risk Management / Quality Assurance Role
Like many healthcare job roles today, risk management plays a vital part in patient safety. This means ensuring software of all kinds, including those running clinical systems, controlling medical devices, or used as standalone applications are safe. Applying a risk management approach will mean considering safety standards for medical software, best practice in software design and the unique application of the software used routinely in healthcare. State of the art guidance, regulations and the MPCE community exist to allow Healthcare Scientist specialising in Clinical and Scientific Computing to support Health Institutions in these areas (6; 8; 9; 10; 11). The role of the healthcare scientist in managing this risk and maintaining quality assurance (QA) processes is essential to the safe delivery of health services.
2.4.2 Risk Management Case Study – Automatic Diabetic Retinopathy
Problem: Diabetic retinopathy is a complication of diabetes, caused by high blood sugar levels damaging the back of the eye (retina). Over time, a persistently high blood sugar level can damage these blood vessels in 3 main stages, eventually leading to loss of vision. However, if a problem with a patient's eyes is picked up early, lifestyle changes and treatment can stop it getting worse. An ophthalmology consultant wanted to use Artificial Intelligence (AI) technology as part of the 4 stage screening process to identify diabetic retinopathy in diabetic patients. The Clinical and Scientific Computing team was asked to help minimise the risk of missing patients with signs of diabetic retinopathy.
Solution: The consultant approached the Clinical and Scientific Computing team to develop a 'First Pass' application that would process patient images and to write algorithms to learn how to automatically identify signs of diabetic retinopathy. A multidisciplinary team was set up to work on the AI software and ensured the application, especially the algorithms, were developed and validated to remove or reduce the potential for harm if signs of diabetic retinopathy were missed. Following detailed validation and clinical assurances, the product has now been placed on the market (12).

2.5 Team Working

2.5.1 Team Working Role
For a Healthcare Scientist specialising in computing to have a clear understanding of the clinical needs of service users, the technology infrastructure and the clinical application's capabilities they will require a significant level of team working. This will involve collaboration in multidisciplinary teams (MDTs) i.e., manufacturers, other hospital staff members (medical/clinical, allied health professionals), engineering, and ICT staff. The Healthcare Scientist, having the scientific, engineering and technical knowledge, will then transpose this team working into solutions that span a broad spectrum of healthcare specialities ranging from design projects to clinical systems, applications and medical device support.
2.5.2 Team Working Case Study – MDT working
Problem: A service has requested a database application to facilitate the recording of Motor Neurone Disease (MND) patient exams and clinical review information. This application will upload patient reports to the Trust Electronic Medical Record.
Solution: The Healthcare Scientist required a clear understanding of the MND service's requirements, necessitating early and frequent communication with the MND Team (including nurses, admin and consultants) to understand the patient care pathway, functional, and performance requirements. The Healthcare Scientist also engaged with other teams such as infection control, Quality Assurance, Information Governance, and ICT, as well as service managers to ensure a successful deployment. The core MND Team and the Clinical and Scientific Computing Team met regularly to review the progress of the project throughout the development of the application, addressing design changes and ensured the MND database met the need of the service.

2.6 Higher specialist registration in clinical computing / consultant level in the NHS.

2.6.1 Higher Level Roles
There are two main routes to higher specialist registration in Clinical and Scientific Computing, a training route and an equivalence route. The training route involves taking part in the Higher Specialist Scientist Training Scheme (HSST) (13), generally sponsored the employing Trust/employer. The course includes a Doctorate in Clinical Sciences (DClinSci) provided by the University of Manchester and vocational

training. There is also a route of equivalence that results in the same accreditation based on a portfolio of work mapped to the same standards as the HSST through the Academy for Healthcare Science (14). The skillset of higher specialist and consultant level healthcare scientists will be required to strategically plan the physical, financial and human resources required to meet future service needs, and persuading senior organisation managers to support and fund this.
The legislative and compliance requirements of procuring, installing, managing, upgrading and decommissioning IT systems is increasingly complicated, requiring a specially trained workforce, which in turn takes years to build.
Example job titles in the NHS may include:
Clinical safety officer (CSO) – The CSO is a registered healthcare professional, experienced in the application of risk management to clinical domains and suitable knowledge of the clinical impact of IT changes. They must ensure that a suitable safety process is in place and that it has been followed correctly. NHS England offers Digital Clinical Safety training to prepare those working in Health and Social Care Organisations and Manufacturers (15).
Information asset owners (IAO) – The IAO is a senior member of staff responsible for understanding: what information is held, what is added and what is removed; how information is moved; and who has access and why. As a result, they are able to understand and address risks to the information and ensure that information is fully used within the law for the public good. They are assisted in the practical aspects of this work by Information Asset Administrators (IAAs).
Responsible person - Under EU Medical Device Regulations (16) the Healthcare Scientist may act in the role as the responsible person for regulatory compliance of medical/clinical software developed within the Healthcare Institution, if the placed on the market or, put into service. The EU Medical Device Regulations is considered by IPEM to be best practice at time of publication (8).

2.6.2 Higher Career Progression Case Study – Description of a higher-level position

> *"As a Head of a Scientific Computing group, the main focus is to direct and manage the development of a clinical scientific computing team. But my role involves more than that, by acting as a lead in Digital Transformation for our department, following the Trust's and NHS digital strategies. At this strategic level, I represent our department in forums to develop strategies for delivering improved operational efficiency through optimal use of commercial software solutions and development and integration of in-house solutions.*
>
> *I also lead the software development for in-house or commercial use, and I am responsible for the implementation and oversight of a comprehensive Software QMS, in order to meet national and international policies and legislation. In conjunction to that, overseeing the Clinical Risk Management for Health IT Systems is also part of my duties. Project management, business process modelling and modern methodologies (e.g., Agile or DevOps) are key ingredients for my role, In this respect.*
>
> *On the R&D and education side, I coordinate multi-professional teams on development of bespoke digital solutions, and I lead and advise on student projects. Additionally, I Identify and establish external collaborations with Academia and Industry regarding scientific computing and software development projects."*

Dr Virgiliu Craciun

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3. Training and education

The formal training route to these roles can be followed in England through the National School of Healthcare Sciences training programs (17) and there are alternative routes across the four UK nations (18). In-job training can be provided through the Association of Clinical Scientists (ACS) (19) and, with a relevant PhD or MSc registration, can be obtained in as little as 3 years. In-job training may also be obtained via healthcare scientist apprenticeships. However, most healthcare scientists currently employed in this role have taken a much more informal route. Most medical physics and clinical engineering jobs involve computing to a lesser or greater degree and some people have chosen to

become computing specialists in their own area of expertise (see case studies). In recognition of this the NHS now provide several funded training opportunities in this area (Topol fellowship (20), NHS digital academy (21), NSHCS Higher Scientific Specialist Training (13)). Finally, anyone working as a Healthcare Scientist can apply for equivalence registration from the Academy for Healthcare Science (14), as long as they can provide a portfolio of work.

4. Leadership

Leadership roles in clinical and scientific computing are required to identify, develop. and translate digital and artificial intelligence solutions to improve healthcare delivery.
For example, the role of cloud computing and artificial intelligence/machine learning in healthcare is rapidly evolving and is seen by many as a tool to reach the targets described in the long-term plan (22) (workforce pressures, financial pressures, and an aging population with increasing demands). Leaders in healthcare need the technical skills to evaluate this technology and bring clarity to how the benefits of these advances can be realised and used safety, according to legislative requirements.
In recognition of this the NHS and universities now provide a myriad of leadership courses for all levels of career and should be used to augment both post-graduate learning and in-job training.

5. What to do next...

If you are interested in this type of role:

5.1 School students

- Watch YouTube videos about the specialism and the routes available (23) (24) (25).
- Contact the IPEM Clinical and Scientific Computing Group (9) for information about subjects to take at school.
- Look at options for T-levels (26) (England only).
- Consider apprenticeships in this area (27).

5.2 School leavers

- Search NHS Jobs (28; 29; 30) for keywords including Clinical Computing, Scientific Computing and Bioinformatics.
- Consider apprenticeships in this area (27).

5.3 University Students/Post-Grad Students

- Contact the Head of Medical Physics and Clinical Engineering at your local Hospital.
- Contact academic departments specialising in Clinical AI.
- Search NHS Jobs (28; 29; 30) for keywords including Clinical Computing, Scientific Computing and Bioinformatics.
- Consider applying for Direct Entry to the Clinical and Scientific Computing Specialism of the STP (2).

5.4 Healthcare Scientists

- Consider applying for In-Service Entry to the Clinical and Scientific Computing Specialism of the STP (2).
- Investigate what the equivalence requirements are (14).
- Contact your Trust's Lead Clinical Scientist or Head of Medical Physics and Clinical Engineering to see what Clinical and Scientific Computing activities are occurring in the Trust.
- Think about taking part in a formal leadership program (31).

5.5 Managers looking to set up a Clinical and Scientific Computing Team

- Contact the IPEM Clinical and Scientific Computing Special Interest Group (SIG) (9) and join the Community space for advice from other members of the community.
- Review the NHS Employers article on Healthcare Science (32).

- Read the Topol Report (5).

6. Glossary

Term	Definition
Artificial Intelligence (AI)	“The use of digital technology to create systems capable of performing tasks commonly thought to require human intelligence” (33)
Bioinformatician	Someone who works within Bioinformatics
Bioinformatics	A specialism of healthcare science that creates and uses large collections of data within a healthcare setting
Clinical pathway	Tools used to guide evidence-based healthcare
Clinical Technologist	“A staffing group responsible for maintaining, monitoring and operating sophisticated equipment and instruments used to diagnose illness and to treat patients” (34)
Deep Learning	“… the subset of machine learning methods based on artificial neural networks with representation learning. The adjective "deep" refers to the use of multiple layers in the network. Methods used can be either supervised, semi-supervised or unsupervised.” (35)
Demographics	the statistical characteristics of human populations (such as age or income) used especially to identify markets (36)
Healthcare scientist	A board category staff within the NHS and public health services covering laboratory (pathology) sciences, physiological sciences, medical physics and clinical engineering and bioinformatics.
Informatics	“An area of healthcare science responsible for developing and improving methods for acquiring, storing, organising and analysing biological data that supports the delivery of patient care” (37)
Information Governance	“The legal framework governing the use of personal confidential data in health care” (38)
Machine learning	“… complex algorithms that learn rules from data, rather than being written by experts” (39)
MATLAB	“... combines a desktop environment tuned for iterative analysis and design processes with a programming language that expresses matrix and array mathematics directly.” (40)
Medical device	A medical device is any device (including software) with a medical purpose. For example, walking sticks, heart monitors and smart watches
Medical physicist	Someone who works within Medical Physics
Medical physics	A specialism of healthcare science that supports, develops and applies physical techniques such as ultrasound, radioactivity, radiation, magnetic resonance to explore or record the workings of the body for diagnosis, monitoring and treatment (41)
Multidisciplinary team (MDT)	A group of healthcare professionals from different fields working together towards a common goal, for example determining a patient’s treatment plan or completing a project
Oncology	A branch of medicine that specializes in the diagnosis and treatment of cancer (42)
Oncology Management System (OMS)/Oncology Information System (OIS)	A system used to manage the entire oncology patient pathway from a referral to treatment, including administrative and clinical activities

Patient Administration System (PAS)	“An information service providing a foundation to all healthcare…. It records non-clinical patient details, such as name, date of birth, and home address, as well as any additional contact details for next of kin in an emergency” (43)
Python	An open source scripting language
Quality	“The ability of a product or service to meet its purpose or consumer [or patient] need” (44)
Quality Assurance (QA)	“The process that ensures quality” (44)
Quality Management System (QMS)	“The overarching system used to achieve and manage quality” (44)
Radiologist	A doctor who specialise in radiology
Radiology	“.. a type of medicine specialising in the use of imaging to diagnose and treat disease seen within the body.” (45)
Radiotherapy	“… a treatment where radiation is used to kill cancer cells.” (46)
Resected	Removed by surgery (47)
Script/Scripting	A programming language that is usually understood by the computer when it is run

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