AI and Digital Healthcare Technologies

Capability framework

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AI and Digital Healthcare Technologies Capability Framework
Digital, Artificial Intelligence and Robotics Technologies in Education (DART-Ed)

This framework was created by Health Education England in partnership with The University of Manchester

Foreword

A clear need for our healthcare workforce is to continually adapt to meet the needs of the society it serves. Following the publication of the Topol Review in 2019, which set the vision of the NHS to prepare the healthcare workforce to deliver the digital future, Health Education England (HEE) commissioned the University of Manchester to perform a learning needs analysis and develop a framework outlining the skills and capabilities to ensure our health and care professionals can work in a digitally enhanced environment. This is part of our wider efforts to co-create reforms in healthcare education and training, whilst ensuring we best support the development of a workforce which responds to changes in healthcare both now and in the future.

During the Covid19 pandemic, we have seen implementation of digital technologies at a faster pace and scale than we ever imagined and have observed how admirably the health and care workforce have adapted to the changes around them. As we expect to see further developments in AI, Robotics, and digital healthcare technologies, it is important that we understand the skills and capabilities the system would need to embed these into existing learning and training pathways. These skills and capabilities should allow our health and care staff (and learners) to work safely and effectively with these technologies in a digitally transformed health and care system.

HEE has recently launched Enhance - its enhancing generalist skills programme, to allow those working in all disciplines to work effectively to meet patient and citizen needs, in the context of improving the health and wellbeing of local populations. Generalist approaches address the needs of the wider system, preparing our staff to work in integrated care systems to understand place-based, population health principles, and to deliver health and care to the local communities around them. The programme will champion person-centred approaches to care, flexible ways of working to manage complexity and co-morbidity, promote social justice, health equity and environmental sustainability. Digital is a cross cutting theme of the programme, with emphasis placed upon being able to critically appraise and champion innovations and digital health technologies to promote and transform sustainable improvements in healthcare. It is pleasing to see several of these themes present in the Capability Framework.

This report presents the framework to allow educators and learners to identify learning needs required to utilise Digital Healthcare Technologies encountered in the workplace, whilst considering the human, social and ethical aspects implications of their use. It presents case studies demonstrating the active role of these technologies in our health and care system and provides valuable understanding of the skills and capabilities that can form the part of future training and curricula. It is part of a series of outputs from our Digital, AI and Robotic Technologies in Education programme (DART-Ed); future work will present an education strategy around AI building on this framework and the user archetypes that are presented. I would like to thank the DART-Ed team and the University of Manchester for their collaboration and hard work that has led to the development of this framework and everyone who engaged with the workshops and survey that helped build the evidence to shape it.

adrian

Professor Adrian Brooke
Medical Director
Workforce Alignment NHS Health Education England
MB ChB, BSc (Hons), MRCP(UK), FRCPCH, MD

Contents

Abbreviations

AI	Artificial Intelligence
AUC	Area Under Curve
BP	Blood Pressure
CE	Conformité Européenne (European Conformity)
DICOM	Digital Imaging and Communications in Medicine
ECG	Electrocardiogram
EEG	Electroencephalogram
EHR	Electronic Health Record
FHIR	Fast Healthcare Interoperability Resources
GDPR	General Data Protection Regulations
HEE	Health Education England
HR	Heart Rate
IMDRF	International Medical Device Regulations Forum
IT	Information Technology
JSON	JavaScript Object Notation
ML	Machine Learning
NGT	Nominal Group Technique
NHS	National Health Service
NICE	National Institute for Health and Care Excellence
NLP	Natural Language Processing
ONS	Office of National Statistics
ROC	Receiver Operating Characteristic
SaMD	Software as a Medical Device
UKCA	United Kingdom Conformity Assessed
UKNI	United Kingdom Northern Ireland marking
UoM	University of Manchester
XML	Extensible Markup Language
XR	Extended Reality

Executive summary

Alongside key delivery drivers, Health Education England (HEE) has established the Digital, Artificial Intelligence and Robotic Technologies in Education (DART-Ed) programme looking to build on the findings and the recommendations made in the 'Topol Review – Preparing the healthcare workforce to deliver the digital future'. With the emergence of technologies described in the review, as well as the ongoing digital transformation we are seeing in the health system, it is important to understand the learning needs of our healthcare professional workforce in respect to digital healthcare technologies, inclusive of artificial intelligence, data driven and robotic technologies.

HEE commissioned the University of Manchester to understand the evidence and undertake further evidence gathering exercises through workshops and survey engagement to inform the development of the capability framework. Workshops were attended by healthcare professionals, industry innovators, educators, and academics. The survey was completed by a variety of professionals including academics, students, clinicians, allied health professionals and digital/IT.

The developed framework builds on previous digital literacy capabilities outlined by HEE and its domains include digital implementation, digital health for patients and the public, ethical, legal, and regulatory considerations, human factors, health data management and artificial intelligence. It is an iterative framework which helps outline the capabilities for healthcare professionals at this point in time and will be further informed in the future by other horizon scanning exercises and productions from the DART-Ed programme.

This capability framework will allow individual learners to understand their needs in the digital healthcare technology space, across various workforce archetypes, of users, embedders, creators, drivers and shapers. It will also give a foundation of capabilities which can be lifted and shifted or adapted to curricular and teaching for our healthcare professionals. In addition it will guide the collation and commission of appropriate, openly accessible, and freely available learning resources for baseline levels of learning, as well as the creation of specialist offers for those needing more advanced skills and hands on learning. This work will be built on by separate productions more specifically related to AI confidence in collaboration with the AI Lab at the NHS Transformation Directorate and Robotics in Surgery education in collaboration with the Royal College of Surgeons.

Key audience members for this report and the enclosed capabilities framework include healthcare professionals, our postgraduate educators, higher education organisations and other education providers, our professional membership bodies, and their regulators. This is a key step in defining what learning is needed to drive digital transformation and develop the necessary skills for our staff and learners to work safely, effectively, and efficiently with emerging technologies.

Introduction

The Topol review[1] released in 2019 outlined a set of recommendations for preparing the National Health Service (NHS) workforce to become world leaders in utilising digital technologies for healthcare delivery to the benefit of patients by delivering the digital future.

Clinical teams of the near future will be required to utilise Artificial Intelligence and digital health technologies effectively and equitably to deliver the healthcare of tomorrow.

> *"AI refers to a broad field of science encompassing not only computer science but also psychology, philosophy, linguistics and other areas. AI is concerned with getting computers to do tasks that would normally require human intelligence."*[1]

In response to this need, Health Education England (HEE) commissioned a learning needs assessment and the creation of a capability framework to aid the learning and development of the healthcare workforce of England.

The capability framework aims to help healthcare workers identify gaps in their current knowledge and areas for preparatory activities to support the digital transformation of the workforce.

> *"Digital Healthcare Technologies is defined as digital products and services that are intended for use in the diagnosis, prevention, monitoring and treatment of a disease, condition or syndrome.*
>
> *This encompasses a broad range of technologies: telemedicine, smartphone apps, wearable devices, software used in clinical settings (such as e-prescribing), point-of-care tests, and extended reality technologies (including virtual reality and augmented reality)."*[1]

The capability framework builds on the foundational digital literacy capabilities introduced in 'A Health and Care Digital Capabilities Framework'[2].

The AI and Digital Healthcare framework extends this with capabilities around the use of health data and the technologies that make use of this data (e.g. apps, wearables, software, etc.). This is further extended with more advanced capabilities for Artificial Intelligence (AI) and robotics.

Capabilities range from an initial awareness through to implementing these technologies in a healthcare environment and supporting digital transformation projects.

Background

The use of digital technology and AI in healthcare provides us with a series of opportunities and challenges (Box 1). Digital disruption has transformed working practices in multiple industries. There is an expectation from the general public that the healthcare domain should keep pace with changes in general society and provide digital services fit for the 21st century. It is also hoped that digital solutions can help to offset the increasing demand for healthcare as people live longer and with more long term conditions[1].

In addition to technology and infrastructure, people need to be placed at the centre of this change in order for it to be successful.

Many of these systems require access to patient data to work effectively. Issues of trust, transparency and digital literacy levels are all challenges that need to be overcome. There is an opportunity for the evolving health workforce to lead this change and empower themselves and patients through the effective and ethical use of these technologies.

BOX 1:

Challenges and opportunities of AI

Adapted from Artificial Intelligence: 'How to get it right' **[3]**

Opportunities

- Diagnostics: uses in image recognition, symptom checkers, decision support systems and risk stratification
- Knowledge generation: drug discovery, pattern recognition, improved knowledge of rare diseases and causality
- Public health: national screening programmes and digital epidemiology
- Systems efficiency: optimisation of care pathways, prediction of Do Not Attends, identifying staffing requirements
- P4 medicine*: personalised treatment, deterioration prediction and prevention advice

Challenges

- » Leadership & society: ongoing communication between areas of government, industry and academia, including international partnerships
- » Skills/talent: skill development for roles in AI development/deployment
- » Data access: innovation through sharing and scaling of data in a fair, ethical and legal way
- » Supporting adoption: Driving public and private sector AI adoption for societal good
- » International engagement: Securing partnerships that deliver access to scale for our eco-system

*P4 = predictive, preventative, personalized, participatory

The impact of AI

AI has the potential to give health and social care practitioners back "time to care" by removing time consuming repetitive tasks that could be easily automated [4, 5]. This also has the potential for further democratisation of healthcare to patients themselves by providing them with information directly.

AI is being piloted in healthcare for tasks such as; faster and more accurate diagnosis, reduction of errors caused by human fatigue, to assist with or automate repetitive tasks, decrease costs and reduce mortality rates [5].

The AI roadmap report and interactive dashboard provides an overview of the current use of AI-driven technologies in the NHS
digital-transformation.hee.nhs.uk/building-a-digital-workforce/dart-ed/horizon-scanning

AI is not without it's challenges though, these challenges include, who controls the data that is used for AI systems, privacy issues, lack of standards for using AI for patient care and liability [5, 6], ethical and regulatory issues around accountability, fairness, transparency and trustworthiness [7] and lack of explainability (the black box) of algorithms [8, 9].

AI algorithms are dependent on the data that is used to train them. This can mean that high accuracy can often be achieved in training models that doesn't necessarily translate into clinical practice.

This means that there is a balance between the opportunities and challenges that AI provides. We also need to manage expectations when we compare the hype with the reality of what AI can and can't do.

Therefore there is a balance between the majority of the health and social care workforce that require a working understanding of the technology, in the same way a clinician using a MRI scanner doesn't need to be an expert in physics but does require an understanding of aspects such as:

when to use the technology, how to interpret it's outputs, an ability to explain the process to patients (and colleagues) and communicate the results [10].

This technology presents a need to change the way health and social care practitioners are trained and educated to make best use of it in order to capitalise on the opportunities presented.

BOX 2:

The future of digital health

Adapted from '*Healthcare Digital Transformation*' **[11]**

The digital health future has the potential to:

» Enable and support online patient access and experiences
» Improve the experiences of caregivers
» Enable use of digital administrative functions
» Enhance health and wellbeing in communities

CASE STUDY:

ASPIRE™: Using Machine Learning to find Undiagnosed Osteoporosis Patients

Osteoporosis is a highly prevalent skeletal disease that causes bones to become weaker and more prone to fractures. In the UK, approximately 33% of women and 20% of men aged over 50 will suffer an osteoporotic fracture. Annual NHS costs of treating these fractures are predicted to rise to over £5.5 billion by 2025. Fractures in the vertebrae, the bone in the spine, are often the earliest clinical manifestation of the disease, so identifying them is key to providing appropriate management to reduce the risk of future, more compromising fractures. Inexpensive drug treatments are available that can halve fracture risk. However, osteoporosis is under-diagnosed in clinical practice. In particular, vertebral fragility fractures (VFFs) are visualised incidentally by approximately 20% of CT procedures in the over-50s acquired for other clinical indications, but only one quarter of them are accurately reported by radiologists and only 2.6% of these patients are referred for appropriate management. The University of Manchester, in collaboration with the Manchester University NHS Foundation Trust and Optasia Medical Ltd., has developed computer-aided diagnostic software to automatically identify VFFs in CT images. It uses machine learning technology to identify vertebrae visualised in CT images and diagnose any VFFs present.

The software forms the basis of ASPIRE™ (www.optasiamedical.com), a tele-radiology. service that allows hospital radiology departments to out-source the secondary reporting of VFFs on CT images. ASPIRE™ combines high levels of automation with oversight from radiologists to improve the efficiency and accuracy of VFF identification compared to in-hospital reporting, whilst reducing clinical workload within radiology departments.

Case study:
A feasibility study to use Machine Learning to support the chemotherapy screening process

The number of patients undergoing chemotherapy is estimated to increase by 5-7% per passing year. This will increase the workload of pharmacists who validate the regimens. Also, in due time more pharmacists will be needed to cover the extra capacity to deal with the increased number of validations.

The process of validating a regimen, called screening, is based on well-defined protocols with set criteria and baselines. 90% of the screenings are proved to be correct with no further actions needed. And only 1-2% of the rest of the screenings lead to a need for change in the regimen prescribed. Working with **The Christie NHS Foundation** Trust we explored whether the use of AI can reduce the time needed to screen a regimen, and therefore free up the time of the pharmacists while supporting a bigger capacity of screenings for chemotherapy patients.

The study aims to assess the feasibility of devising a new AI tool to be embedded in existing workflows to support the decision process for regimen selection within clinical systems, as well as to formulate the framework in which ML work-flows can facilitate improved patient outcomes and optimise operation clinical pathways.

- » Provide a sound basis on which to evaluate the completeness and accuracy of data for the purposes of initially validating prescribed regimens leading to decision support for regimen selection within clinical systems.
- » Provide efficiencies for the pharmacy department through freeing up staff from a manual process.

We are following an Agile-inspired methodology based on an incremental and iterative approach to collect information needed and develop data journey models representing the data landscapes. We work closely with the stakeholders involved in the workflows and patient pathway, establishing ongoing communication channels, and taking into consideration their feedback.

An initial analysis based on a focus group and observation sessions with a lead pharmacist on Trastuzumab SC EBC regimen, showed that the screening workflow

can be supported by a decision support tool to flag up regimens that require extra verifications to be made by a pharmacist. The majority of pharmacists' time lies in tracking the right documents in time-order to identify the latest values. This leads to an opportunity for a tool/solution to support the data provenance of information integrated in the data warehouse.

PERSONAS

Michael Smith
Clinical Scientist (R&D)

Research scientist working in radiotherapy, AI implementation, evaluation and development. Experience in medical imaging, medical devices, radiation oncology, statistics, data-science.

Technology expertise	Excellent
Digital health tech experience	Excellent
Experience with AI systems	Excellent

Devices owned/used

IPhone • IPad, Laptop/desktop PC • Heart rate monitor

Needs

Time • Money • Food

Challenges

Information Technology (IT) • Information Governance (IG) • Lack of clear standards/guidelines • Engagement of tech companies with ethical AI and evidence generation

Goals

Enable robust and ethical implementation of algorithms • Maximise clinical benefit of technology • Appropriate confidence in algorithms and AI for healthcare

Age
38

Location
Liverpool

"I don't like tech, but used right it's a powerful tool."

Framework domains

6.0 Artificial Intelligence (AI)

6.1 Machine learning and natural language processing

6.2 Using and implementing AI systems

6.3 Evaluating AI systems

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Impact on education and learning needs

CASE STUDY:

Assessing organisational readiness for embedding AI tools in the POA phase of an orthopaedic pathway

Predicting outcomes is a key part of the patient care pathway before undertaking orthopaedic surgical procedures. Artificial Intelligence tools exist to enhance the accuracy of risk prediction for surgical outcomes by clinicians using data held within Electronic Health Records. But evidence of such tools being embedded in practice is limited. Health care organisations need further understanding on why AI tools might be difficult to embed in organisations including what costs and risks they may face.

We worked with Ramsay Health Care UK to perform a feasibility study to assess organisational readiness for implementing Artificial Intelligence/Machine Learning (AI/ML) tools in the pre-operative assessment phase of an orthopaedic service and understand the social and technical costs/risks involved in the transformation.

We undertook an agile-inspired approach utilising the LOAD model and data journey model to map the existing data landscape of the organisation and identify potential socio-technical barriers and risky areas when implementing the AI tool. Domain expertise was gathered from 6 subject matter experts through semi-structured interviews. Potential next steps that mitigate the highlighted costs/risks are suggested.

The data journey model clarified that the organisation does collect all relevant data required to produce an evidenced based AI/ML risk prediction tool. Significant boundaries to effective implementation were predicted such as limited access to structured data, actor interactions introducing errors, costs of changing the media of data and the costs of transferring data across organisational boundaries.

Results showed that whilst the organisation does collect the relevant data required to produce an evidenced based AI/ML risk prediction tool, significant social and technical boundaries to effective implementation were predicted. Limited access to structured data can risk ineffective deployment of the prediction tool. The need for the AI/ML tool to access the required type of data will result to significant process transformation costs and heavy reliance of actors to consume and transform the data types between existing data containers.

Organisations should understand their existing data landscapes, data journeys and associated social and technical costs and risks of implementing AI/ML based tools before embarking on such projects to prevent unforeseen costs or failure.

Health and social care workers will need to adopt additional skills to work effectively with AI. A recent survey of 210 doctors found that 92% reported insufficient AI training in their current curricula [9].

This suggests that some of the time that was previously spent on memorizing medical/clinical/health information may need to be devoted to the development of new skills in order to safely and effectively use AI systems and tools in practice.

Proposals for incorporating AI into educational training included skills such as:

- » Knowledge of mathematical concepts
- » Fundamentals of AI and data science
- » Related ethical and legal issues
- » Data input skills
- » Communication of the outputs of algorithms
- » Ability to communicate AI derived results to patients

Adapted from [5, 9]

In contrast to these skills and knowledge, emotional intelligence will also increase in importance when dealing with patients physical and emotional states [12]. More advanced capabilities surrounding domains like AI and robotics are in turn dependent on the use of patient data. This data and it's quality is integral to the success (or otherwise) of an AI system [13].

The success of data-driven AI projects can be further increased through the application of a collaborative team based approach which combines interdisciplinary skills and knowledge with domain knowledge [13]. It is not possible for people to be experts in all areas given the complexity of the medical/health and technology domains, instead multidisciplinary team work and an understanding of roles with the development of a common shared language and understanding can help move us toward a successful digital future.

The workforce

As of August 2021 there were 1,198,746 NHS hospital and community health service staff working full time [14]. The NHS has also seen a steady increase (16.9%) over the last five years of the informatics workforce in England [14].

The capability framework provides capabilities for a wide section of the workforce, ranging from patient facing practitioners such as nurses, doctors, dentists, pharmacists, paramedics, physiotherapists and other allied health professionals, to those with a more data centric role such as bio-informaticians, and data analysts/scientists.

Some staff also have mixed roles with both a clinical dimension and an element of their role focused on IT/digital/informatics projects. The number of different roles and multiple positions (different hats) people have makes developing a framework aimed at multiple professions extremely challenging. To overcome this issue the framework is based around a series of 'archetypes' that represent the type of activities that different individuals may be involved with. Most NHS professionals will sit within one archetype, however some roles may span across several archetypes. The framework can be applied flexibly to different situations accounting for this variability in roles and workflows.

CASE STUDY:

eConsult Specialist

The overwhelming pressures across the National Health Service (NHS) are putting a strain on service delivery nationwide, and the challenge opens scope for innovation. eConsult have already transformed the delivery of primary care services with over one million eConsults being completed each month – a digital questionnaire that collects key patient information to allow clinicians to improve triage.

Following the rapid growth, eConsult has ventured into Urgent and Emergency Care and outpatients, each of which comes with a whole variety of complexities and challenges. eConsult has partnered with Mid and South Essex NHS Foundation Trust to deliver a patient management system that will reduce the waiting list backlog, reduce Did Not Attend (DNA) rates, revolutionise triage, digitalise Patient Initiated Follow Up (PIFU) and improve patient experience simultaneously. Over 40 outpatient speciality departments will be implementing a specialist list of questions to allow triage at the outpatients' referral stage.

Although this will be the first roll out across an entire Trust's outpatient department, eConsult has been working with the Cardiff and Vale acne clinic trialling a smaller scale project. In doing so, eConsult reduced the patient waiting list clearance time from 20 years to just 3 years in addition to reducing DNA rates from 40% to nearly zero.

The collaboration is merely the start of outpatient transformation that will serve long term benefits to the NHS. Supporting workforce has been crucial to the implementation of this project and a suite of resources have been pulled together to support staff with this new way of working.

CASE STUDY:

Whzan remote monitoring supporting high quality care for care home residents in North Central London

Care home residents often have complex health needs which increase their risk of deterioration in the community. Since the start of the covid-19 pandemic a need has emerged to be able to offer remote care to care home residents, especially given the increased risk of adverse outcomes from covid-19 outbreaks in this population. North Central London (NCL) CCG worked in partnership with NCL training hub, NHSx and Solcom to embed the Whzan blue box in care homes. This remote monitoring kit enables care home residents to have their observations taken by staff, after which a NEWS2 score is calculated and the information automatically entered onto a tablet and portal via Bluetooth. This data can then be accessed via clinicians across the local healthcare system.

150 care homes have been trained up by a team of nurse educators on how to take observations using Whzan, recognise soft signs of deterioration and communicate with clinicians using SBAR. >43,000 NEWS2 scores have been taken on 3384 care home residents over a 12 month period. Care home staff report increased confidence in recognising when someone is unwell along with feeling empowered in conversations with clinicians by having additional patient information. GPs, community matrons and MDTs are able to use the data to support triaging patients and clinical decision making when doing telephone or in person reviews. Across all care homes using Whzan there has been a 28% reduction in LAS call outs. The process of embedding this digital technology in care homes using a collaborative approach in NCL has strengthened relationships between staff working for the NHS, Local Authority and Adult Social Care with benefits realised for both residents and staff.

Archetypes

Shapers

This can include people in leadership positions in the NHS and other arm's length bodies, regulators, policy-makers and professional educators.

Drivers

This can include clinical commissioners, service/ digital transformation leads, CIO/CCIO.

Creators

Clinical specificalists/scientists, software engineers, data scientists and AI/Computer science researchers

Embedders

IT teams, data teams, clinical scientists/specialists, clinical safety officers

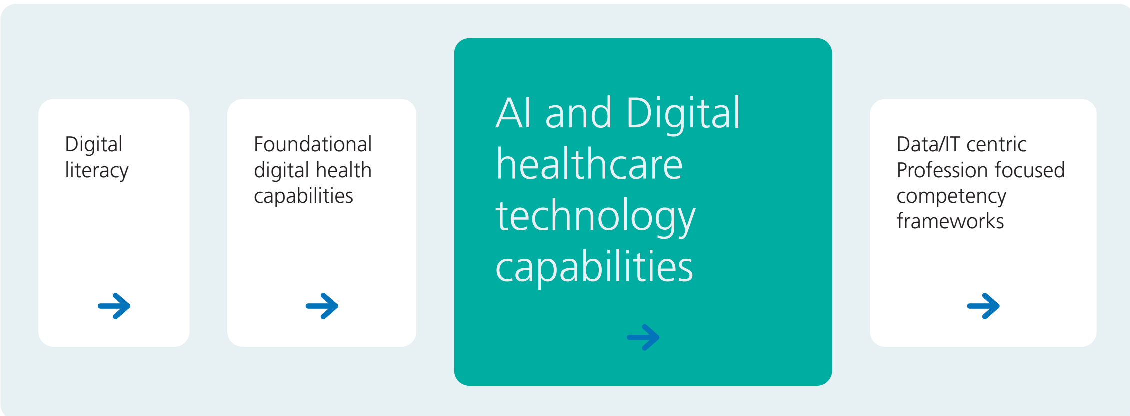
Users

End users such as healthcare professionals, clinical researchers and other non-clinical staff that use AI and digital technologies

The current landscape

There are several competency and capability frameworks currently available in this space so why do we need another one?

The AI and Digital Healthcare Technologies framework straddles the space between the foundational digital capabilities[2] that were based on the Jisc digital capacity framework and competency frame-works aimed at specific data and IT centric professionals, such as the Faculty of Clinical Informatics (FCI) Core Competency Frameowrk[16] or the Federation of Informatics Professionals (FedIP)[17].



The framework focuses on building capabilities rather than developing core competencies which more specialist frameworks focus on. This framework specifically focuses on digital health technologies and their use, including AI and robotics. It is envisaged that users of this framework can already meet the appropriate capabilities and competencies for their specific role but want to develop their digital skills to safely and effectively interact with healthcare technologies.

Certain data centric groups may also have specific frameworks such as that provided by CILIP for library and information management personnel[18] or those identified by the Associated of Professional Healthcare Analysts (AphA) report[19]. There are also international offerings for certain professional groups, such as bio-informaticians (ELIXIR) and nursing informatics (TIGER).

There is currently no UK based framework for Health Data Scientists in the NHS or those professionals that will be looking towards the implementation of AI systems. This new framework aims to span the gap between fundamental digital capabilities and the advanced frameworks that target specific professional groups by providing a middle ground for a larger proportion of the work-force who will be expected to develop their knowledge, understanding and capability so they can use and apply these technologies.

PERSONAS

Naomi Femi

GP registrar

GP registrar passionate about creating innovative tech solutions to healthcare problems. Several years' experience working in the healthtech industry both as an AI clinician and as a clinical advisor to start Ups. Interested in how we can prepare the workforce for the introduction of AI.

Technology expertise	Good
Digital health tech experience	Good
Experience with AI systems	Good

Age
27

Location
London

Devices owned/used

• Laptop (Mac) • IPad, Smartphone • Smart TV • Smartwatch • Kardia device (remote ECG)

Needs

Support with learning digital health skills while training • Training pathways that support gaining experience in digital health • NHS job roles that allow me to use digital health skills

Challenges

Lack of exposure to data science and product management skills in clinical training so having to develop these skills separately • Digital health work not recognised as part of training • No clear career path-way to senior digital health roles e.g. CCIO

Goals

Career that combines clinical work and digital health innovation • Produce innovative tech solutions to healthcare problems to improve the lives of both clinicians and patients

> *"We need to make it easier for trainees to develop digital health skills and continue clinical training or we'll end up losing the people most willing and able to produce innovate digital solutions from the NHS workforce."*

Framework domains

2.0 Digital health for patients and the public

6.0 Artificial Intelligence (AI)

6.1 Machine learning and natural language processing

6.2 Using and implementing AI systems

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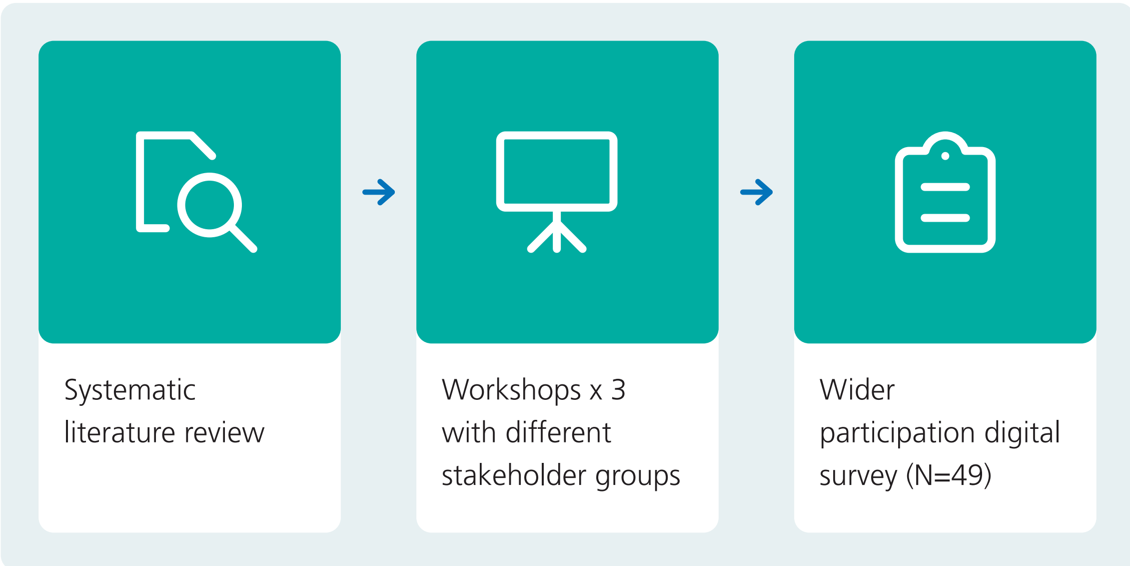
Capability framework

Methodology

The framework was generated utilising a mixed methods approach that applied co-design principles. A systematic literature review was carried out identifying academic papers. Other sources of information were also included, such as related national and international frameworks, policy documents and reports.

Main topics/themes were extracted and loosely grouped under headings as a bullet point list. This was used to stimulate discussion at 3 workshops targeting different groups of stakeholders.

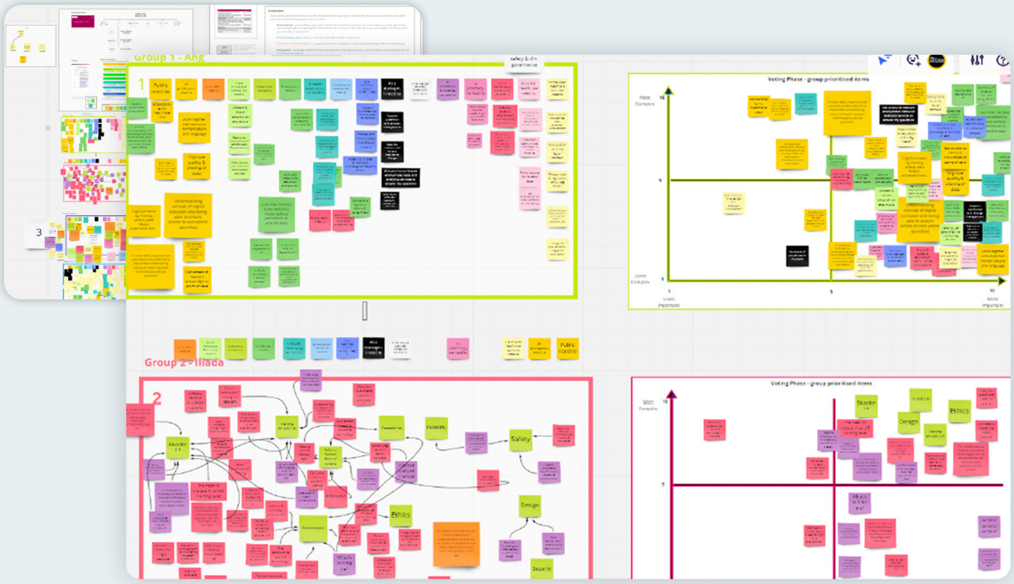


The three workshops were carried out with multiple stakeholder groups. Workshops took place online using Zoom and collaboration software called Miro. The nominal group technique was used to facilitate the workshops (see box 2).

The first workshop was aimed at early career digital leaders (i.e. Topol digital Fellows and NHS Clinical Entrepreneur Fellows), the second included industry representatives (i.e. Babylon Health, Google Health, Bupa and Barclays) recognising that much of digital transformation comes via partnerships with industry. The third and final workshop included educators and subject mater experts.

A draft framework was produced as a result of these workshops which was then distributed via digital survey. Following feedback from 49 respondents, the framework was updated following a recommended iterative design approach[20,21] leading to the version seen in this report.

Three workshops were carried out with multiple stakeholder groups. Workshops took place online using Zoom and collaboration software called Miro. The nominal group technique was used to facilitate the workshops.



Screen shots of the Miro board from one of the three workshops ↗

BOX 2:

Phases of the Nominal Group Technique (NGT)

Nominal phase: Gives people the chance to consider information silently and individually. This was done offline prior to the workshop

Item generation: A round-robin idea generation phase. This was carried out during the workshop with ideas captured on the Miro board

Clarification and discussion: Items read aloud by facilitator. Participants can ask questions and seek clarifications about the ideas generated

Voting: Finally a voting phase is carried out where ideas are placed on a grid which indicates their perceived importance and complexity

PERSONAS

Frank Field

Allied Health Information Officer

I am an AHP Information Officer and practicing musculoskeletal physiotherapist within a large London Teaching Hospital. I am also a former Topol Fellow at Health Education England, and developed the UK AHP Digital Competency Framework.

Technology expertise	Good
Digital health tech experience	Good
Experience with AI systems	Good

Age
30

Location
London

Devices owned/used

• Laptop • iPhone 11 • Apple watch 7

Needs

• Good access to work-force data based upon digital competencies • Systems which share data across organisational boundaries • A comprehensive info resource database to aid development of clinicians on healthcare technology

Challenges

• Poor understanding of AHP roles and responsibilities • Variability in digital tech use across organisations • Variability in digital skills and knowledge • Poor data sharing across systems to enhance patient care

Goals

• Promoting development of a digital pillar of practice for all AHPs • Enhancing use of pop-health level data to aid clinical pathway development • To uplift the digital skills and knowledge of all AHPs in the UK

"Currently the healthcare environment stands behind other aspects of daily life, where technological-enablement is ubiquitous."

Framework domains

1.0 Digital transformation

2.0 Digital health for patients and the public

4.0 Human factors

4.1 Management, leadership, and plannng

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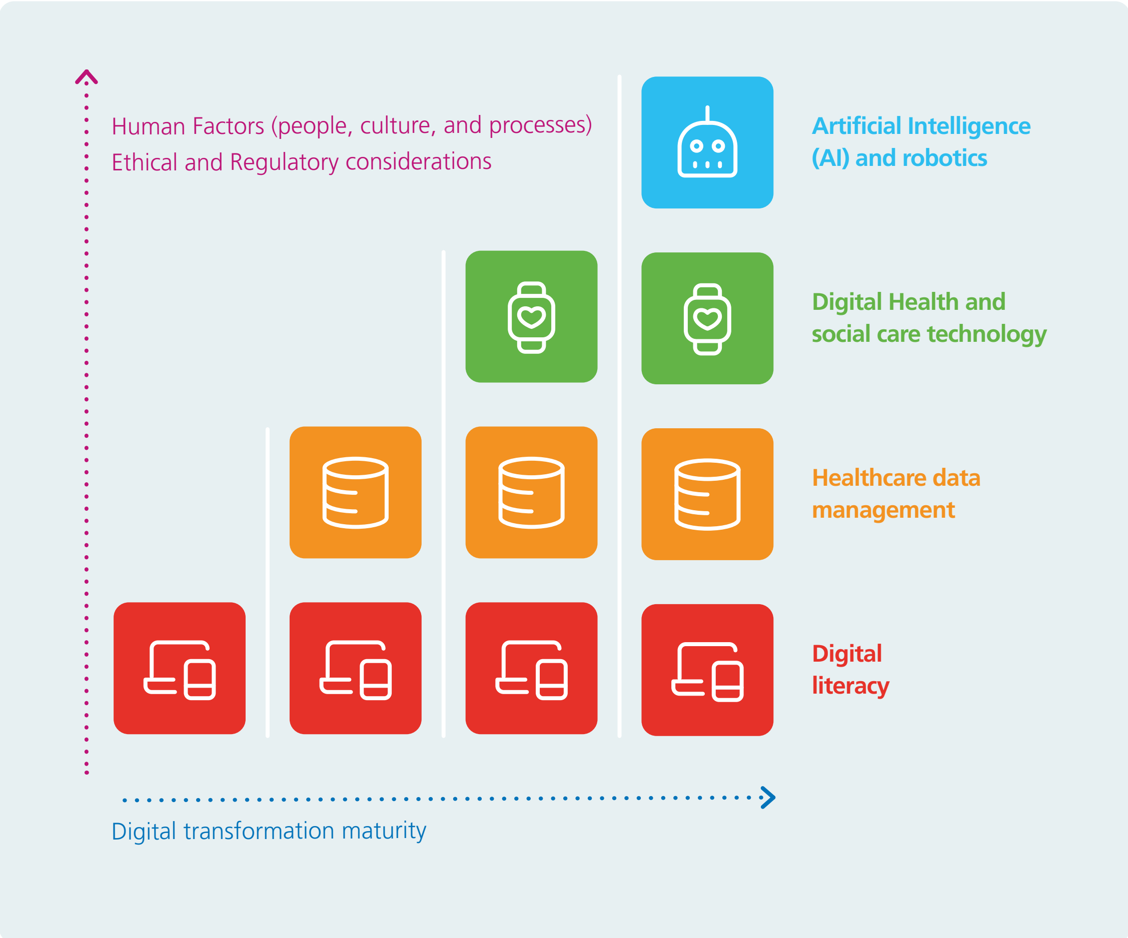
Framework

The framework is built on top of the general digital literacy skills which act as the foundation for digital health and social care. The next level relates to healthcare data and data literacy. Data powers many of the more advanced technologies and digital enablers such as apps, wearables and electronic health records. Following on from this and also based on data we have the more advanced capabilities related to artificial intelligence and robotics. Throughout these levels are human factors, such as people, culture and processes as well as ethical and regulatory considerations. Finally the ability to combine and advance the use of these technologies demonstrates different levels of digital maturity in an organisation. Digital transformation extends throughout the described stages as infrastructural and cultural changes are required in the first instances to develop, use and innovate these technologies to bring value to patients and the public. These concepts can be visualised in the figure below:



Each of the frameworks 6 domains is split into 4 knowledge levels (1 to 4). Within the levels, capabilities are arranged using Blooms digital taxonomy[22] from lower order thinking skills to higher order skills.

Bloom’s Digital Taxonomy

Individual capability statements in the framework in each level are ordered based on Bloom’s digital taxonomy.

The taxonomy moves from lower order thinking skills (bottom) to higher order thinking skills (top).

The digital taxonomy defines a hierarchy of learning activities that can be applied to a digital environment.

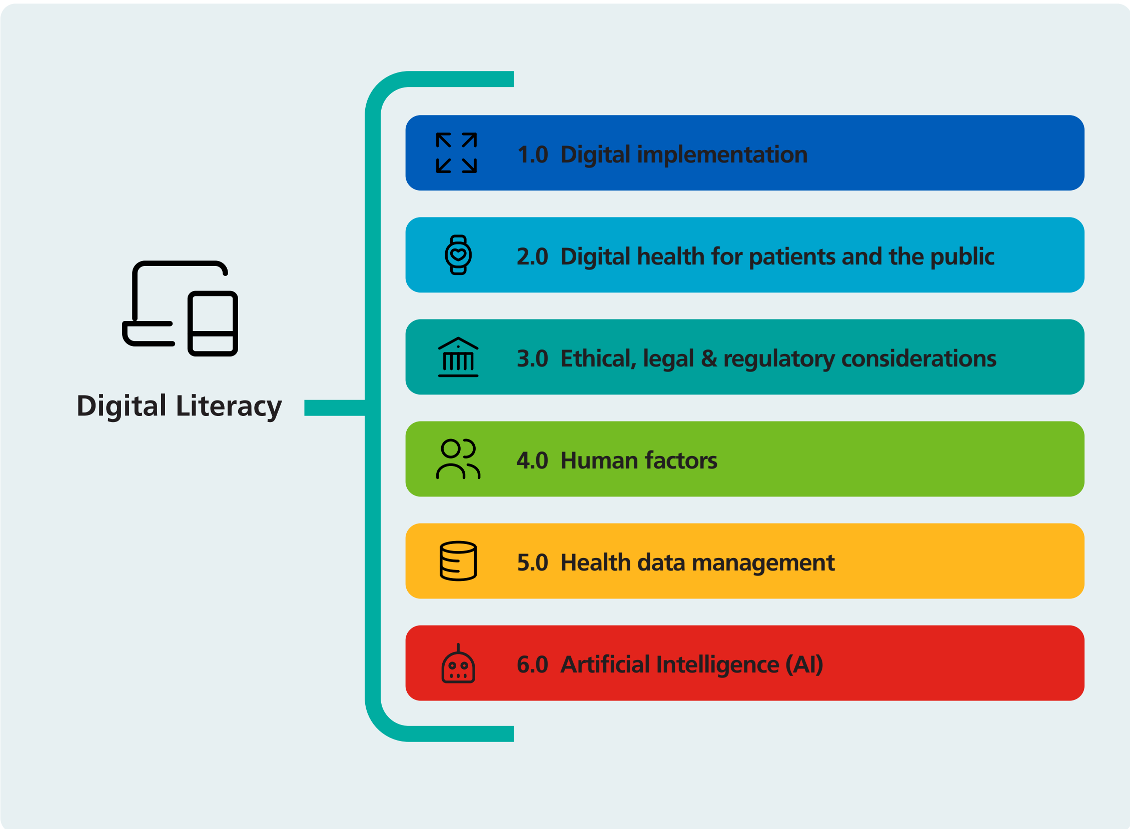
This can be used for tasks such as lesson planning and curriculum design.

Framework structure

The framework is built on the foundation of basic digital literacy. This literacy also extends through the framework concerning literacy with more advanced concepts such as AI and robotics. The framework consists of 6 primary domains consisting of 11 sub-domains and 195 individual capability statements.

The six primary domains consist of:

1. Digital implementation
2. Digital health for patients and the public
3. Ethical, legal & regulatory considerations
4. Human factors
5. Health data management
6. Artificial Intelligence



The six primary domains and sub-domains can be seen in the image below. The colours are used to identify which domains/sub-domains the capability statements belong to.

Digital Literacy

1.0 Digital implementation

2.0 Digital health for patients and the public

- **2.1** Providing direct care with digital technologies
- **2.2** Remote consultation and monitoring

3.0 Ethical, legal & regulatory considerations

- **3.1** Ethics
- **3.2** Legislation and regulation

4.0 Human factors

- **4.1** Management, leadership, and plannng
  - **4.1.1** Management
  - **4.1.2** Leadership

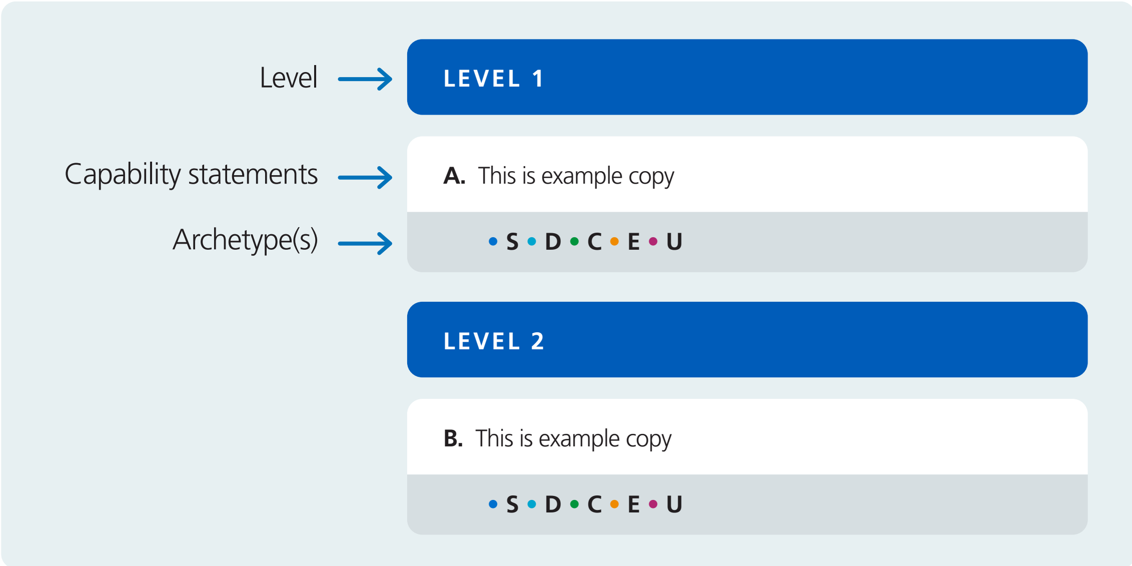
5.0 Health data management

- **5.1** Data management and processing
  - **5.1.1** Data collection and context
  - **5.1.2** Data storage
  - **5.1.3** Data visualisation and reporting
  - **5.1.4** Data processing and analytics
- **5.2** Data/cyber security
  - **5.2.1** Data privacy and confidentiality

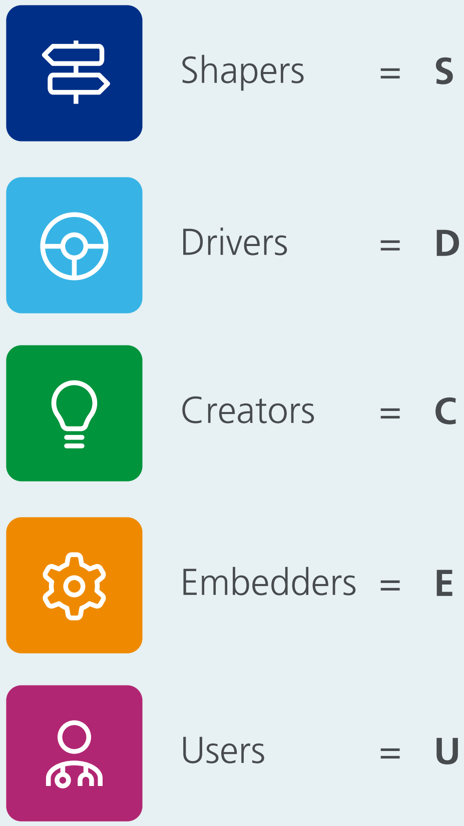
6.0 Artificial Intelligence (AI)

- **6.1** Machine learning and natural language processing
- **6.2** Using and implementing AI systems
- **6.3** Evaluating AI systems
- **6.4** Robotics

Each of the capability statements are grouped into related sections and sub-sections. They are further grouped into 4 knowledge levels that increase in complexity and depth from 1 to 4.



Each of the capabilities are badged with the archetypes introduced previously that are most relevant for a particular capability statement. Therefore you can review capabilities by topic and matching archetype to which you identify against.



1.0 Digital implementation

Different organisations are at different levels of digital maturity. Digital implementation acts as an enabler for the subsequent technologies of Artificial Intelligence (AI), robotics and digital health. This includes working with multidisciplinary teams as well as having the required infrastructure for supporting digitisation and attitudinal willingness to engage in changing current practices and processes, along with meeting the challenges associated with transformative goals.

LEVEL 1

A. I am aware of a variety of digital enablers and can distinguish the main features of each (e.g. the web, EHRs, tablets, mobile apps, smartwatches, etc.)

• S • D • C • E • U

B. I am aware of the digital technologies available to me in my role, and how to access training to become competent to use these technologies

• S • D • C • E • U

LEVEL 2

C. I have an awareness of accessibility issues among different patient/user populations and how to mitigate against the risk of widening inequalities as a result of introducing digital technologies and can provide or recommend suitable alternatives if required or requested

• S • D • C • E • U

D. I develop my professional practice to work with other experts and teams to support digital implementation, both within my professional community and wider (e.g. contributing lessons learnt with others/wider team)

• D • C • E • U

LEVEL 3

E. I can investigate, record and communicate socio-technical factors that may impact the adoption of digital technology implementation in my organisation

• D • E

F. I am aware of the potential environmental implications of digital transformation (e.g. the carbon footprint of training certain AI models which can be an energy intensive process) and attempt to offset this impact by improving efficiency once systems are deployed

• S • D • C • E

LEVEL 4

G. I can capture and model existing information/data pathways in my organisation in order to understand the current workflows and to prepare for digital transformation projects

• D

H. I am able to assess and implement the required infrastructural changes to physical environments to support digital transformation (e.g. digitally integrated operating room)

• D • E

2.0 Digital health for patients and the public

Digital Health is the convergence of health and social care with digital technologies to provide and improve healthcare provision and efficiency. This covers a range of technologies and tools including mobile apps, wearable technologies and telehealth. These technologies can be used for patient communication and monitoring as well as direct delivery of care and interventions.

LEVEL 1

A. I am aware of a variety of digital NHS resources available that are relevant to my role or my team (e.g. apps/websites) and can give guidance to patients to access and use them appropriately and provide support (e.g. with care and/or increasing knowledge about their health)

• **S** • **D** • **U**

B. I am able to identify and find alternative solutions to maintaining emergency care where digital systems fail or are identified as failing

• **D** • **E** • **U**

C. I am proficient at recording and accessing clinical observations accurately and securely in an electronic record system for clinical/health care

• **U**

D. I can recognise situations where patients encounter "digital exclusion" and proactively ensure alternative access to care when identified

• **S** • **D** • **C** • **E** • **U**

E. I can explain digital health information to patients to support them in making data-driven decisions about their health (e.g. health risk scores/metrics [QRisk, PROMs])

• **C** • **U**

F. I respect patients' preferences around the use of digital technology and empower & support them to make informed choices about technology used in their care

• **S** • **D** • **U**

G. I can evaluate and recognise the pros and cons of automated systems (e.g. triage, symptom checkers) used in the NHS and can help signpost to inform and guide patients and users when access to such systems is appropriate to their care

• S • D • U

LEVEL 2

H. I can confidently explain to patients what AI systems in my specialism/area of practice are doing in a broad sense and can tailor my explanation accordingly with awareness that patients have different levels of digital literacy

• U

I. I can initiate conversations with patients to improve their understanding of data collection, use and data security

• U

LEVEL 3

J. I can clearly explain to patients how their data will be collected, stored and safeguarded by systems recommended for their care/research and their respective rights

• U

K. I can critically appraise resources aimed at improving digital literacy for health and support members of the public to find and assess appropriate data or health information

• S • D • U

L. I actively promote digital inclusion and can help patients improve their digital literacy by signposting them to appropriate resources to assist them with technology we intend them to interact with

• S • D • C • E • U

LEVEL 4

M. I can recommend digital resources through policies and guidelines to patients and the public for various health conditions based on the Digital Technology Assessment Criteria (e.g. apps through the NHS website)

• S • D • U

N. I can provide training and education to health care professionals that train patients and the public to improve their digital literacy skills using formalised pedagogical approaches (e.g. using techniques such as 'teach-back' and 'chunk and check')

• **S** • **D**

2.1 Providing direct care with digital technologies

The evolution of healthcare towards a more digitally integrated system brings with it both benefits and challenges. Some patients are avid users of technology and want to be able to engage with a modern health service with their existing devices, some preferring electronic communication for convenience. In contrast other patients will require a lot of help and support to bridge the 'digital divide'. The healthcare system needs to strive to increase support and trust in new ways of interacting with patients and the public through digital means.

LEVEL 1

A. I am aware that a variety of sensor devices are available to the general public and that these devices are not necessarily approved for clinical purposes and that as such the quality of the data collected may not be of sufficient quality/reliability for use in remote patient monitoring and care based decision making

• **D** • **U**

B. I can work in adapted clinical environments integrated with digital technology safely and effectively (e.g. digitally integrated operating room, virtual wards)

• **U**

LEVEL 2

C. I am technically proficient in the use of common computational devices (e.g. smartphones, tablets, desktop and laptop computers) to facilitate clinical interactions and view/edit records using software relevant to my discipline (e.g. health information systems)

• **U**

LEVEL 3

D. I am aware of and can define digital/eHealth and related sub-categories (e.g. uHealth, mHealth and Telehealth/medicine)

• S • D • C • E • U

E. I am aware of and can describe Extended Reality (XR) and its sub domains (e.g. virtual reality, augmented reality and mixed reality)

• S • D • C • E • U

F. I can define the term ‘digital twin’ (a digital representation of a real world object, service or process) and can give examples of their use in healthcare (e.g. bed/hospital management)

• S • D • C • E • U

G. I am able to customize and configure eHealth solutions for use in clinical practice and can troubleshoot common issues arising from such solutions

• D • E • U

LEVEL 4

H. I create opportunities to engage patients and the public in the design of digital solutions that reflect their needs and priorities (e.g. co-design, user centred design principles with patient groups)

• D • C

I. When applying AI processes to direct patient care, I am able to second-check decisions made by automated processes to ensure they meet the required standards of safety and quality and know how and where to report concerns if they fail to meet these standards

• S • D • E • U

2.2 Remote consultation and monitoring

Digital technologies offer the potential to provide remote consultation and monitoring of patients. This can be especially useful for rural settings and routine procedures. Remote monitoring can also free up resources and allow patients to remain in their own environments and/or live more independently whilst still receiving medical care and monitoring.

LEVEL 1

A. I recognise the benefits and risks of using different messaging platforms for patient communication and always abide by the recommendations of my organisation regard-ing preferred tools to achieve this safely and securely

• **E** • **U**

B. I recognise the role of remote patient monitoring for care (e.g. post-surgical intervention) and how this can support monitoring and safety of patients at increased risk (e.g. in remote/rural areas)

• **S** • **D** • **C** • **E** • **U**

C. I always use workplace recommended systems to facilitate secure messaging and file transfer (e.g. cryptographically secure tools)

• **S** • **D** • **C** • **E** • **U**

D. I can carry out patient consultations, facilitate secure real time audio/visual communication tools, interpret data collected with these tools and make decisions based on these data

• **U**

LEVEL 2

E. I am aware of the stages involved in remote care pathways from consultation through to remote monitoring and applying digital interventions in my speciality/area

• **S** • **D** • **C** • **E** • **U**

F. I can advise members of the public on preparing for a consultation online and support a shared decision making discussion in line with NICE shared decision making guide-lines[23]

• **U**

LEVEL 3

G. I am confident in the use and troubleshooting of digital tools to facilitate secure real time audio/visual communication (e.g. patient consultations, internal/external meetings with other healthcare providers and groups) and can adapt my consultation approach to remote consultations for the majority of my patients

• **E** • **U**

H. I am aware of different digital remote monitoring options that are available to patients in my area/speciality (e.g. mobile apps, implantable/wearable devices and home sensors) and can communicate the basic operation of these options to others

• D • E • U

I. I can provide user support to help patients setup remote monitoring technology and collect data through biosensors

• E • U

J. I am able to use, interpret and critically appraise data provided by individual patients (e.g. collected by commercial wearables) and use this to promote patient wellbeing, health and the prevention of disease

• S • D • C • E • U

LEVEL 4

K. I can explain to patients and the public how wearables related to my area of practice work in terms of what data they collect, how the data is collected from the wearer and any available data sharing options

• U

L. I can recommend (through accessing policies/guidelines) different remote monitoring options that are available to patients in my area/speciality (e.g. mobile apps, implantable/wearable devices and home sensors)

• D • U

M. I can interpret large quantities of remotely collected telemetry data with appropriate tools to monitor patients and use insights derived from this process for decision making in patient care

• C • E • U

3.0 Ethical, legal & regulatory considerations

Legislative systems are currently unable to match pace with the rate of advancement of new digital technologies. There are also many ethical concerns surrounding the use of technologies such as AI in society, especially in medical care. Such tools have the potential to increase or continue to reflect pre-existing biases and inequalities, as well as increase the digital divide for some people. To address these concerns, ethical and regulatory frameworks and considerations should be at the forefront of decision making regarding the application of AI and digital technology in order to promote equity, fairness and transparency.

3.1 Ethics

LEVEL 1

A. I champion a culture of ethical responsibility around the use of AI & digital technology to ensure that systems and processes are fair, transparent, equitable and non-discriminatory to patients, staff and the wider public; espousing the principles of beneficence, non-maleficence & autonomy

• **S** • **D** • **C**

B. I know how to access up to date guidelines and knowledge about digital systems at the point of care and only use such systems I am trained and competent to use, recognising my own limitations and competence

• **U**

C. I always ensure that appropriate consent for data sharing has been granted prior to processing, storing or sharing data

• **D** • **C** • **E** • **U**

LEVEL 2

D. I am aware of ethical considerations around information governance for digital health technologies including remote consultations/monitoring (e.g. consent, recording of consultations and sharing of images etc.)

• S • D • C • E • U

E. I am aware of the ethical issues of automating clinical decision making or relying on algorithms and digital technology that are not fully transparent/understandable

• S • D • C • E • U

LEVEL 3

F. I am aware that data collection tools and systems should be designed to account for patient/user diversity so that the output of data processing/analysis will not cause or increase health inequalities

• S • D • C • E • U

G. I am aware of the need for citizen consent and am fluent in the reasons and actions taken to protect and enshrine public trust

• S • D • C • E • U

3.2 Legislation and regulation

LEVEL 1

A. I abide by legal requirements and directives regarding the access to and processing of data (e.g. GDPR, Data Protection Act 2018)

• D • C • E • U

B. I am aware of the potential litigious consequences of a data breach to my organisation (e.g. fines, damage to reputation) and actively take steps to prevent this by abiding by my organisations standards and guidelines

• D • C • E • U

LEVEL 2

C. I am aware of the legal, ethical & accountability implications for my organisation of using AI for augmented clinical decision making

• S • D • C • E

D. I am aware of the legal, ethical & accountability implications for myself and organisation when following or overruling AI based recommendations in augmented clinical decision making

• U

E. I am aware that legislation may not keep pace with technological innovation. Where clear regulations do not exist I aim to apply the ethical principles of beneficence, non-maleficence, autonomy and justice as a guide to using digital technology (e.g. promoting principles of privacy, confidentiality and equality)

• S • D • C • E

F. I am familiar with the governance requirements (including UKCA/UKNI, CE marking) for medical devices including software and AI concerning regulation, quality management, testing and ongoing monitoring

• S • D • C • E • U

LEVEL 3

G. I am aware of clinical evaluation frameworks (e.g. IMDRF[24] recommendations, NICE evidence standards framework for digital health technologies[25]) that can be used to clinically evaluate software and AI as a medical device

• S • D • C • E

H. I am aware of how to determine if a given automated system has been appropriately validated for use in its intended clinical context and has undergone a clear, transparent approval process

• D • C • E

I. I am aware of issues around consent and medical negligence (e.g. Bolam, Bolitho, Montgomery v Lanarkshire)[26] and the challenges of applying these to AI and digital technologies

• S • D • C • E • U

J. I understand regulatory approval does not guarantee the performance of a medical device or algorithm in any given context

• S • D • C • E • U

LEVEL 4

K. I am aware of the different wearable remote monitoring devices and ensure that when recommended to patients they have appropriate regulatory approval (e.g. CE, UKNI or UKCA mark)

• D • E • U

4.0 Human factors

At the centre of these technologies are people, organisations and processes. Delivering digitally driven change requires strong management and leadership skills and abilities; such as change management as well as providing oversight that accounts for factors like organisational culture/needs and understanding of existing workflows and patient pathways.

LEVEL 1

A. I acknowledge the need for multidisciplinary collaboration to ensure the safe and effective use of digital health and AI technology

• S • D • C • E • U

B. I am aware of specialists roles and teams involved in AI and digital healthcare (e.g. informaticians, software/data engineers, IT specialists, researchers, specialist clinicians etc.)

• S • D • C • E • U

LEVEL 2

C. I am able to assess the potential impact of embedding digital technologies and AI into clinical workflows through engagement with affected teams and individuals

• D • C • E

LEVEL 3

D. I am aware of the level of my organisation's digital maturity and its strategy for digital transformation

• D • E

E. I promote and initiate effective communication between key stakeholders during the implementation of a digital technology/AI system

• D • E

F. I work effectively with technology industry partners to procure digital services and tools (e.g. data storage, computing resources, AI technology) and recognise the advantages and disadvantages of out-sourcing, on-premises and co-creation options

• D • E

LEVEL 4

G. I practice patient/user centred design. I work with patients and users to gather and produce requirements (e.g. user stories, personas, UML diagrams, etc.), set priorities and evaluate and integrate technologies

• C

H. I can clearly explain the strengths and weaknesses of a variety of digital technologies to non-technical stakeholders to facilitate effective collaboration

• D • C • E

I. I can discuss the challenges associated with my organisation's digital transformation strategy and discuss potential technological solutions that may address them, including consideration of the impact of these technologies on patient outcomes and wider organisational goals.

• D • E

4.1 Management and leadership planning

Digital innovation and transformation is led by the culture of an organisation and is often shaped from the top down by strong management with a clear aligned vision and strategy for achieving change. This is also supported by leadership at all levels that takes a proactive role in driving change for improvement at all levels of an organisation. The technologies need to enhance and improve existing processes and add real value. Management and leadership skills are essential in manging the transition to new ways of working, identifying opportunities and removing barriers to success.

4.1.1 Management

LEVEL 1

A. I can effectively use information derived from data driven approaches for the purposes of management planning (e.g. data summaries via digital dashboards)

• S • D • C • E

B. I am confident applying formal change management methods and implementation science to digital transformation projects

• D • E

LEVEL 2

C. I am aware of the need to ensure retention of core skills when introducing digital technology. I ensure back-up pathways are in place to be used in situations when digital technology fails

• D • E

D. I appreciate that responsibly designed and implemented digital technologies and AI systems has potential to increase efficiencies, reduce costs and support healthcare staff to deliver better care

• S • D • C • E • U

E. I am able to recognise an adverse effect (e.g. failure of technology, introduction of biases, inequalities) of an automated or data enhanced pathway and can take steps to rectify this within my organisation

• D

F. I am proficient in carrying out cost-benefit analysis of the impact of new technologies on healthcare systems

• C

LEVEL 3

G. I am aware of software and project management methodologies (e.g. Agile, Lean) and the pros and cons of the different methods for different types of projects

• D • E

H. Following AI/digital technology implementation I can effectively monitor and evaluate AI systems and digital technology projects to ensure they align with financial, clinical and organisational objectives and ensure ongoing effectiveness

• D • E

I. I am able to carry out a review of existing technologies and consider how these can be utilised to meet the strategic goals of my organisation

• C • E

LEVEL 4

J. I know how to identify the quality assurance (verification and validation) of AI systems and digital technologies in my locality based on local policies and guidelines

• D • E

K. I create protocols for the safe use of AI and digital technology in my organisation/area based on evidence (e.g. risk assessment). I define the situations in which the technology will be used and by whom

• C • E

L. I am able to evaluate the most appropriate technical solution to a problem including AI/digital technology. This includes reviewing financial, technical and logistical considerations

• S • D • C • E • U

4.1.2 Leadership

LEVEL 1

A. I actively promote appropriate confidence for healthcare professionals regarding the use of digital technology in healthcare

• S • D • E

B. I lead and enable others to support the development and use of digital technologies, supporting national guidelines and agendas

• S

LEVEL 2

C. I recognise the need for protected time and space for professionals to access appropriate learning resources related to digital technologies. I support a learning culture and emphasise the importance of continuing professional development in digital skills and capabilities

• S • D

D. I can recognise different kinds of expertise in staff interacting with AI and digital technology and can effectively bring together and leverage this expertise to implement these technologies successfully

• D

LEVEL 3

E. I actively identify key problems in clinical areas and have an awareness of how digital technologies and AI can be used to address identified problems

• **D** • **E**

F. I am familiar with digital clinical safety and have implemented an effective contingency/mitigation plan

• **D**

LEVEL 4

G. I lead a digital transformation strategy for my organisation which considers both short and long term goals and determines metrics to measure success

• **C** • **E**

H. I actively sponsor, recognise and promote individuals who demonstrate excellence and maturity in the capabilities found within this document

• **S** • **D**

5.0 Health data management

Data and its management form the foundation of more advanced technologies and methods. Various digital healthcare systems and AI models are dependent on the data that is available to them. The management and processing of healthcare data is therefore foundational to the functioning of these more advanced systems and technologies. Data drives and underpins the accuracy of algorithms; analysis methods and tools used to make data derived or assisted decisions. This includes where and how data are stored as well as data-flows and how they are applied to various pathways (e.g. patient journeys). We all share a responsibility to ensure the data quality throughout these processes from initial collection and storage through to its application in systems and services.

5.1 Data management and processing

An understanding of data stewardship is important to ensure that good quality data is used as input for these systems to generate an appropriate output. This includes awareness of data sharing, governance and regulatory issues as well the more technical aspects of data storage, security and processing.

5.1.1 Data collection and context

How data is collected and the context of data is vital for interpreting the output of data analysis methods and deriving useful and actionable insight form data.

LEVEL 1

A. I am aware of different sources of health and social care data (e.g. ONS data, census data, patient registries, hospital episode statistics etc.) and how to access them, including ethical and information governance requirements

• S • D • C • E • U

B. I am proficient in the use of standardised, validated tools for data collection and extraction, related to my area of specialism

• S • D • C • E • U

C. I am proficient at entering data into digital systems and devices accurately, completely and correctly and recognise the importance of this for data-driven digital healthcare

• U

LEVEL 2

D. I recognise the importance of understanding the health and care data context (how and why it was collected) and the effect on subsequent data interpretation

• D • C • E

E. I am aware of sources of data bias and how biases may affect data interpretation or predictive models; and that this can reinforce existing societal inequalities

• S • D • C • E • U

LEVEL 3

F. I can explain the key differences between structured and unstructured data with relevant examples related to my area of expertise

• D • C • E

G. I am aware of opportunities and challenges of "big data" (e.g. volume, variety, velocity and veracity)

• S • D • C • E

LEVEL 4

H. I am able to develop (and use) metadata standards, taxonomies ontologies and classifications for the storage and retrieval of data, to ensure interoperability and standardisation

• C • E

I. I am proficient in assessing the reliability of data and the appropriateness of tools used to produce or collect data (e.g. databases vs Excel)

• C • E

J. I actively support users with compliance with research requirements relating to data collection. I support them in building competence in these areas

• D • E • U

5.1.2 Data storage

How data is stored securely and its longer term retention is important for the maintenance and accessibility of data as well as the speed and ease of data retrieval and sharing.

LEVEL 1

A. I am aware that data can be stored locally (local storage on servers) or remotely (e.g. cloud storage requiring an internet connection)

• S • D • C • E

B. I am aware of different systems used to store health and clinical data (e.g. Electronic Health/Medical Records, registries, patient generated data sources, genomics databases, secondary data sources etc.) and the impact of this on subsequent data analysis and access (e.g. retrieving data from different database systems)

• S • D • C • E • U

LEVEL 2

C. I am aware of the data storage requirements for my organisation and adhere to these requirements (e.g. where to store data, how to deidentify data and which formats to use)

• D • C • E • U

D. I am proactive in the maintenance of data to ensure its integrity, including the backing up/archiving of data and the options available in my workplace

• E • U

LEVEL 3

E. I am aware that data can be stored in different types of database (e.g. relational databases, document based databases, graph databases)

• C • E

LEVEL 4

F. I can design systems and infrastructure for data storage with a focus on accessibility, privacy and security

• C • E

5.1.3 Data visualisation and reporting

Tailoring the presentation and communication of data to multiple stakeholders with different levels of data literacy is important for decision making, research and resource allocation.

LEVEL 1

A. I am proficient at interpreting information presented in a variety of commonly used visualisations (e.g. bar charts, histograms, pie charts, scatter plots)

• S • D • C • E • U

B. I can use interactive data dashboards to view summaries of data in my domain of expertise

• S • D • C • E • U

LEVEL 2

C. I am proficient at interpreting and summarising data from dashboards and other tools relating to my area of expertise

• S • D • C • E • U

LEVEL 3

D. I am capable of identifying suitable methods of visualisation for different data types

• D • C • E

LEVEL 4

E. I can evaluate the quality of data to ensure is fit for purpose to be used for reporting/communicating findings, and only report on data that meets this standard

• D • C • E

F. I am proficient at interpreting information presented in a variety of specialised visualisations relevant to my field of practice (e.g. Kaplan–Meier curves, OncoPrint, Circos etc.)

• C • E • U

G. I can create data dashboards to summarise, visualise and present data to a variety of stakeholders

• **C** • **E**

H. I can create a range of visualisations for a variety of audiences (e.g. technical and lay audiences) to present data visually for data exploration and reporting using appropriate visualisation design theories

• **C** • **E**

5.1.4 Data processing and analytics

To extract actionable insights form data it must first be processed and analysed. This involves transforming data into a format where analysis methods may be applied and applying these methods with an understanding of which approach to apply based on the characteristics of the data and the intended goals.

LEVEL 1

A. I am aware of the importance of data provenance, data transparency and audit

• **C** • **E**

B. I have an awareness of Information governance processes and procedures when dealing with organisations external to the NHS and adhere to local guidance when dealing with external entities

• **C** • **E**

LEVEL 2

C. I am aware of health data sets available to me in my area and the types of clinical questions that could be answered with these data. I am aware that public datasets may have been processed and that this may make them unsuitable for certain applications

• **C** • **E**

D. I am able to critically analyse a health dataset in terms of the clinical questions it could answer and develop a data analysis strategy (e.g. a plan of how the data could be analysed to answer these questions)

• **C** • **E**

LEVEL 3

E. I am aware of and know how to access secure and trusted IT resources for tasks like high performance computing and cloud based data storage

• S • C • E

F. I recognise and promote the use of common data standards (e.g. FHIR, DICOM, JSON, XML) where appropriate to store and share data

• C • E

G. I can query healthcare databases applying analytical tools to analyse large datasets for audit & research purposes

• D • C • E

H. I promote the use of data provenance for data transparency and audit, and how this can impact on subsequent decisions made using data

• S • D • C • E • U

I. As someone working with data for research, monitoring or process improvement purposes, I know how to effectively deidentify/pseudonymise data

• C • E

LEVEL 4

J. I am able to filter data to derive a subset of interest for further processing/analysis using statistical/programming tools (e.g. SPSS, Excel, Python, R)

• C • E

K. I am confident at applying data linkage and integration into composite data sets and record steps taken (e.g. metadata, audit trail)

• C • E

L. I know where to look to find relevant anonymised datasets and trusted analytics services

• C • E

m. I understand fundamental statistical principles and can use statistical and software tools (e.g. Python, R, SPSS, Tableau, Stata, Power BI) to analyse data

• C • E

N. I understand the pros and cons of different statistical methods for different analysis tasks

• C • E

O. I can take account of data provenance issues when reporting the results of analysis (e.g. which populations were included/excluded, the source of the data and it's context and how it has been transformed/filtered prior to analysis)

• S • D • C • E • U

P. I am confident in the use of Learning Health Systems in daily practice for continual improvement of care and can factor in generated knowledge to adapt my practice and improve processes accordingly making decisions based on data

• U

5.2 Data/cyber security

To ensure public trust and to meet legal requirements, health and clinical data should be protected from loss (or leakage), theft and attack while being processed, stored and shared.

LEVEL 1

A. I abide by the organisational regulations and guidelines aimed to prevent data loss and theft, including when data is being stored and transferred

• S • D • C • E • U

B. I understand and comply with cybersecurity standards in my organisation by keeping my training record up to date

• S • D • C • E • U

C. I am able to access and act on requirements communicated to me about new security threats (e.g. emails from IT personnel asking me to carry out a certain action or be aware of particular threat)

• S • D • C • E • U

LEVEL 2

D. I understand the need for data encryption to protect data and use this where appropriate to store and transfer data

• S • D • C • E • U

LEVEL 3

E. I regularly update systems (e.g. installing routine software updates when prompted) to protect systems/equipment from cyber-attacks

• E

F. As someone who procures technology (e.g. mobile technology, electronic record systems), I ensure that such technology is secure for the purposes of storing and transmitting data

• D • E

G. I am proactive in learning about and implementing security protocols and applying recommended data/cyber security standards

• S • D • C • E • U

LEVEL 4

H. I am capable of championing the education of other staff/users in the security issues related to health technology and promote best practices in maintaining the security of health systems

• S • D • C

5.2.1 Data privacy and confidentiality

Health and social data contains sensitive information about individuals. The principles of privacy and confidentiality are important for maintaining and improving public trust in organisations collecting and processing data.

LEVEL 1

A. I am aware of the need to maintain confidentiality and privacy of health and social care data at all times respecting the data subjects right to privacy

• S • D • C • E • U

B. I always ensure that the data subject is informed of the reasons why data is collected, stored and who will have access to their data and for what purposes

• C • U

LEVEL 2

C. When sharing data, I always ensure that only those with a legitimate reason to view or access the data are included in data sharing to prevent the leaking of sensitive information to those without permission or need to access/view data

• D • C • E • U

LEVEL 3

D. I am aware of the risks of re-identification of pseudonymised data (e.g. using data matching) and can assess and document if further steps are required to further de-identify data

• C • E • U

E. I am aware of and can apply de-identification (anonymization) to data and recognise its importance for maintaining the confidentiality of data subjects and sources

• S • D • C • E • U

F. I am familiar with the architecture and reasoning behind creating TRE's (Trusted Research Environments) and apply/use them wherever appropriate

• C • E

LEVEL 4

G. I practice the application of analysis methods to reduce the risk of re-identification of pseudonymised data

• S • D • E • U

H. I maintain a closed loop consent process with data providers including the citizens and model openness, transparency and accountability for its use

• D • C

6.0 Artificial Intelligence (AI)

AI refers to the ability of machines to mimic human intelligence or behavioural patterns. In practice this often refers to the automation of various activities that involve tasks like finding patterns in data, and making predictions.

LEVEL 1

A. I understand that AI is an umbrella term used to define digital technologies capable of performing tasks commonly thought to require human intelligence. I am aware AI is common in modern technology and can list uses of AI outside healthcare (e.g. voice recognition, recommender systems, self-driving cars, image and video processing)

• S • D • C • E • U

B. I can provide examples of AI systems used in healthcare and understand their potential benefits and risks (e.g. imaging diagnostics and decision support tools)

• S • D • C • E • U

C. I am aware that "machine learning" is a subset of AI and is an umbrella term used to refer to techniques that allow computers to learn from examples/data without being explicitly programmed with step-by-step instructions

• S • D • C • E • U

LEVEL 2

D. I am aware that all AI applications in healthcare are defined as 'narrow' AI that are trained to perform a particular and specific task

• S • D • C • E • U

E. I can identify the contribution that AI could make to healthcare processes in my area of practice and how it has potential to benefit the organization, workforce and patient

• D • C • E • U

F. I can articulate the risks and limitations of AI relevant to my professional area and consider them in my use of AI

• D • C • E • U

LEVEL 3

G. I can explain intellectual property issues pertaining to AI models and how this impacts on AI algorithms co-developed between the NHS and commercial providers

• D • C • E

H. I can define the sub-fields of AI and machine learning and their key applications (e.g. computer vision, audio processing, knowledge representation, natural language processing, expert systems)

• S • D • C • E • U

LEVEL 4

I. I can describe the main types of bias that could affect AI systems (e.g. reporting, selection, group attribution, implicit)

• D • C • E • U

J. I can take steps to identify and mitigate bias in AI systems, such as designing models inclusively (human centred design approaches), training with representative data and testing for bias

• D • C • E

K. I understand the importance of and promote transparency of AI models used within my area of practice. For example, identifying the type of model used, training data, methods and potential model limitations and weaknesses

• C • E

L. I understand the benefits and limitations of AI explainability. I keep abreast of research and developments in this area and am aware of the potential impact on confidence in clinical decision making

• C • E

6.1 Machine learning and natural language processing

Machine Learning (ML) is a sub-set of AI. Machine learning and natural language processing offer models and techniques for making predictions and classifications with large amounts of data. They can do this without the need for the explicit programming of step by step instructions, learning instead from the data provided.

LEVEL 1

A. I understand that machine learning algorithms require large quantities of data to learn from, and must be trained and evaluated using independent sub-sets of the available data

• S • D • C • E • U

B. I am aware of some of the common uses for Natural Language Processing (NLP) methods and text mining within and outside of healthcare (e.g. chat bots, speech/virtual assistants, dictation of clinical notes, processing electronic patient records)

• S • D • C • E • U

LEVEL 2

C. I am aware of the use of virtual assistants (e.g. Amazon Alexa, Google Assistant) in healthcare to improve accessibility for patients (e.g. patients with disabilities) to access health information and can recommend their use to patients where appropriate

• U

D. I understand the differences between AI for prediction (prospective) and AI for explanation of existing data (retrospective). I am aware of the risk of conflation of these use cases

• S • D • C • E

LEVEL 3

E. I am familiar with core concepts and methodologies used in the field of Machine Learning (e.g. data science, statistics, mathematics, computer programming)

• C • E

F. I am aware of different learning methods and their suitability for a clinical task based on the available dataset (e.g. supervised, unsupervised, reinforcement learning)

• C • E

LEVEL 4

G. I am familiar with model evaluation metrics (e.g. sensitivity, precision, recall, F1 score, Area under Receiver Operator Characteristic Curve (AUROC), Precision Recall Curve (PRC), mean error, mean absolute error, calibration) presented in academic papers and can use these to evaluate machine learning algorithms

• **C** • **E**

H. I am confident in critically appraising literature regarding performance and validation of an AI solution for my area of expertise, comparing it to alternatives and to the current standard of care

• **C** • **E**

I. I can critically assess the model development process of a machine learning solution (e.g. feature labelling/extraction, dimensionality reduction, normalisation, model selection and tuning hyper-parameters)

• **C** • **E**

6.2 Using and implementing AI systems

AI systems often have to be tailored for specific situations and uses. In the healthcare environment it is less likely that processes will be entirely automated. This often involves humans working with AI systems (human in the loop) where AI systems automate some (usually routine or repetitive) tasks to free up time for specialists to focus on other areas. This sees a closer working relationship between human experts and AI systems.

LEVEL 1

A. I am able to use AI systems confidently to assist me to improve task efficiency while maintaining quality and safety

• **U**

B. I know how to respond if an AI system fails or is inaccessible and can initiate an alternative process to maintain effective service provision

• **E** • **U**

C. I understand the importance of sharing learning following failures of an AI system, to improve systems and practice

• C • E • U

LEVEL 2

D. I am aware of the limitations of AI systems and how to respond when AI derived information contradicts my clinical/professional intuition. I retain a 'critical eye' and am aware of how AI may influence my decision making

• U

E. I can justify the use of AI in specific clinical scenarios and know when it is and isn't appropriate to implement an AI solution based on desired outcomes, potential risks and organisational goals

• D • E

F. I actively maintain my clinical knowledge and skills to ensure that my clinical performance is not adversely affected by de-skilling resulting from using AI

• U

LEVEL 3

G. I am aware of the various stages of implementing an AI system, including risk assessment, interoperability, workflow integration, validation & verification, user training, on-going monitoring and model iteration

• D • C • E

H. I can set thresholds for monitoring patients using AI enabled decision support systems for chronic health conditions to generate alerts to initiate appropriate action (e.g. call patients in for review, alter treatment)

• D • C • E • U

LEVEL 4

I. I am confident at selecting suitable AI methods for given use cases

• C • E

J. I understand the potential benefits and limitations of data augmentation, including data simulation and synthesis techniques when there is little available data for training AI systems. I can design testing using real-world data to ensure robustness of AI models trained in this way

• C • E

K. I can effectively cost AI-driven solutions taking into account factors such as initial set up, workforce, maintenance and other running costs (e.g. cloud storage costs), balancing these against potential efficiency savings

• D • C • E

6.3 Evaluating AI systems

Once AI systems have been implemented they need to be evaluated to ensure they are safe and fit for purpose. Algorithmic drift can occur prompting the need for continual readjustment. The system also has to be evaluated in the local context to ensure it is configured correctly and working optimally for the chosen goals.

LEVEL 1

A. I can explain the difference between internal validation, external validation, local evaluation and prospective clinical evaluation of AI technology and their relevance to clinical performance. I am aware of recommended standards for validation of different types of AI technologies used in healthcare (such as the NICE evidence standards framework for the digital health technologies).

• D • C • E

B. When evaluating an AI system for use in my professional workflow, I can compare its performance against the expected standards in my professional area of practice

• D • E • U

LEVEL 2

C. I am aware of the challenges of bias and generalisability for AI algorithms (the ability to perform well in a different demographic group or clinical context to that used for evaluation). I am able to evaluate the publicly available evidence supporting an AI tool and identify the need for further evaluation in my local setting

• D • E

D. I am aware of the potential ways in which use of an AI solution may affect human decision makers (e.g. human cognitive biases around the use of AI and AI derived information, such as automation, anchoring and confirmation biases)

• D • E

LEVEL 3

E. When commissioning AI technologies, I can discuss the requirements for safety testing (e.g. user acceptance testing, quality assurance testing), in addition to algorithm performance evaluation

• D • E

F. To improve performance of AI systems—I am aware that 'optimisation' can be used to discover a sub-set of potential 'best choices' of model once some AI analysis has been carried out

• D • E

G. I can discuss the clinical validation standards and approval phases for healthcare AI models and understand the importance of continual post deployment surveillance

• D • E

LEVEL 4

H. I am aware of recommendations that for evaluating and reporting of AI interventions in clinical trials (e.g. SPIRIT-AI[27], CONSORT-AI[28]) and can apply these where appropriate

• D • E

I. I can communicate potential benefits (improved consistency, availability, speed, efficiency) and challenges (e.g. model explainability, biases, model under/over fitting) of using AI systems in healthcare to various stakeholders

• D • E

J. I am able to carry out post market surveillance and ongoing clinical monitoring to determine if the system is still meeting required needs and to identify model decay (e.g. the tendency for AI model performance to drop over time as (e.g. the tendency for AI model performance to drop over time as data and patient characteristics change, requiring models to be regularly updated)

• D • E

6.4 Robotics

Robotics builds on many of the AI technologies and represents the intersections of these areas. Robots are being used for routine cleaning and disinfecting procedures, logistical processes, high risk areas (e.g. highly infectious individuals) and surgical tasks through to providing companions for the elderly. Robotic technology takes on various forms and applications and is set to increase in use in the near future as the technology improves and the cost reduces.

LEVEL 1

A. I am aware of the use of robotic technology for healthcare and can cite examples of the use of robots for health, medical & social care (e.g. social companion robots, surgical robots, room disinfectant robots, nanotechnology, etc.)

• S • D • C • E • U

LEVEL 2

B. I am aware that robotics comprises an intersection of most areas in AI (e.g. cognitive modelling, computer vision, natural language processing, machine learning and affective computing)

• D • C

C. I am aware of the uses of telepresence robots to carry out basic procedures (e.g. temperature monitoring) in highly infectious patients and for use with elderly to support independence or for remote care and assessment

• S • D • C • E • U

LEVEL 3

D. I know where and how to access training (local or manufacturer provided) on robotic technology that I am expected to use

• E • U

E. In my domain, I can work confidently with robotic technology and recognise the limits of such technology and when to override or desist use (e.g. safety reasons, malfunction, etc.)

• U

F. I am responsible for demystifying the use of robotics and democratising its use and integration within appropriate pathways

• S • D • C • E • U

LEVEL 4

G. I am confident in critically appraising literature regarding robotics for my area of expertise in terms of their applications, limitations, required resources and suitability

• S • D • C • E • U

H. As someone who instructs others to use robot-assisted surgery - I am able to identify and agree clear training goals with those I instruct

• D • C

I. As someone involved in procurement of robotic technology/solutions, I can effectively cost a solution taking into account factors such as initial set up, maintenance and other running costs

• D

PERSONAS

Marta Bąk

Dentist

Dental specialist trainee working in Community Dental Services. Lives with partner in a rented flat. No siblings, family do not live locally. Fit and well. Enjoys going to the gym, outdoor walks and vegan cooking.

Technology expertise	Average
Digital health tech experience	Average
Experience with AI systems	Poor

Age
31

Location
Liverpool

Devices owned/used

• Laptop • iPhone 7 • iPad mini

Needs

• Provision of equipment for access to patient records • Access to training in using digital tech and data management • Digital leads to support team development

Challenges

• Lack of integration of systems with wider health/social care net-works • Poor technical infrastructure (e.g. no WiFi) • No e-prescribing • Paper-based systems still often used and requiring additional clinical time

Goals

• To support patients with flexible adaptive pathways • Upskill wider Dental Care Professional (DCP) team • To access, understand and utilise patient population health data relevant for the region and its needs

"We need to upskill the wider Dental Care Professional (DCP) team, so members are able to work to their maximum potential to support delivery of oral health care."

Framework domains

1.0 Digital transformation
2.0 Digital health for patients and the public
2.2 Remote consultation and monitoring
3.0 Ethical, legal & regulatory considerations
4.0 Human factors
5.0 Health data management

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Applying the framework

... and next steps

Framework application

The digital healthcare technology domain is fast moving and dynamic, as such the framework is not intended to be a static document but the starting point for an evolving and continually changing living document. This can be overseen through setup and use of a working group.

Who does the framework apply to?

The capabilities in the framework describe the skills and knowledge that the health and social care workforce should be aware of and actively developing depending on their role. Due to the fluid nature of some roles that can span clinical and IT fields the use of archetypes was adopted so individuals and managers can best identify which are likely to apply depending on the nature of a persons role and duties.
The framework is intended to help people identify which capabilities they may be lacking in order to help them focus on those areas that are likely to be directly relevant to their role as healthcare adopts more technology and embraces digital transformation.

How can the framework be used?

- This can be used by individuals to identify and target gaps in their learning
- By educational providers to map their courses and programmes against and as a basis from which to develop educational resources
- Employers and managers can use this to identify the training needs of their staff and for strategic planning purposes
- Can be used to identify appropriate training and educational courses and resources

The future

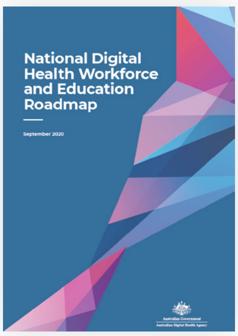
Digital maturity

Many healthcare organisations are at various stages of digital maturity in their digital transformation journey. At the earlier stages, organisations are focused on extending their EHR systems to add value and improve patient access, mostly relying on the vendors 'product roadmap'.

Others have moved further and are focusing on particular capabilities such as telehealth and mHealth apps. Further along, need is being addressed through the development of stand alone digital health initiatives that were created to address near term issues and priorities. The more advanced models are applying an overall strategy to digital transformation that includes the priorities of various stakeholders and investing in infrastructure and digital enablers for a sustained longer term enterprise level roadmap.

Adapted from [11].

The HEE DART-Ed programme is currently developing further products which will more specifically understand the educational requirements and offer needed around AI, building on this capability framework and the AI confidence framework [30, 31] as well as understanding Robotics Surgery literacy needs with the Royal College of Surgeons through their RADAR initiative. The DART-Ed will continue to monitor through horizon scanning exercises other emerging technologies and their impact on the healthcare workforce, and the necessary skills and training needed to prepare our healthcare professionals for these developments.



International collaboration

With the development of digital technology, many countries are also exploring preparing the workforce for digital transformation. Understanding and working with others to develop best practice in a global context is increasing in importance in a more connected world. An example of this is the work Health Education England have been doing by collaborating with the Australian Medical Council through a series of roundtable events to explore areas of common interest shared by the UK, Australia and New Zealand on digital health and medical workforce development.

PERSONAS

Isobel Bark

Emergency dept nurse practitioner

Isobel works as a nurse practitioner in the Emergency Department in a regional trauma centre, is happily married and husband is also a nurse in ED. She uses a mix of paper and electronic systems to care for her patients and would like to see how these systems can be joined to provide safe care for her patients.

Technology expertise	Below average
Digital health tech experience	Average
Experience with AI systems	Poor

Age
28

Location
Newcastle

"I need to see all of my patient's medical record in a single place so I can make sure I am making the right decisions for the patients to provide the best care possible."

Devices owned/used

- Desktop PC
- Smartphone
- iPad

Needs

- Confidence in safety of the patients medical record and their care
- Smooth processes so all patient's are seen quickly
- Would like to work with the IT department to improve digital capability in her department

Challenges

- Worries might miss important info when using different (sometimes difficult) systems/processes
- Paper medicine charts will be lost and has to remember what was given – sees hundreds of patients during shift so knows this would be difficult

Goals

- Would like to see all of the patient record in a single electronic system
- Find information needed easily
- Reduce the amount of manual input
- Stop duplication of information on paper and electronically

Framework domains

2.0 Digital health for patients and the public
2.1 Providing direct care with digital technologies
3.0 Ethical, legal & regulatory considerations
3.2 Legislation and regulation
4.0 Human factors
4.1.2 Leadership
5.1.1 Data collection and context
5.1.2 Data storage
5.1.3 Data visualisation and reporting
5.1.4 Data processing and analytics
5.2 Data/cyber security

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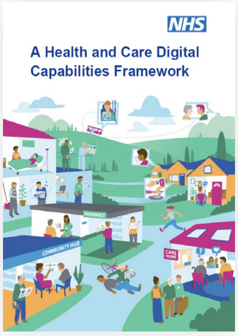
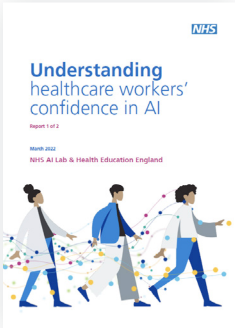
Useful resources

The following represent a none exhaustive list of some of the excellent resources around digital healthcare technology and AI.



A Health and Care Digital Capabilities Framework

The Health and Care Digital Capabilities framework focuses on the core digital capabilities needed by those working in health and care. This is presented in four levels against six domains of digital literacy adapted from JISC.
Health Education England (HEE)



Understanding healthcare workers' confidence in AI

The report focuses on building confidence in the use of AI technologies, including when and how to use AI safely, ethically and effectively
Health Education England (HEE) and the NHS AI Lab

Evidence standards framework for digital health technologies

A description of the evidence standards framework for digital health technologies. The report includes evidence of the effectiveness of technology for the purpose of supporting developers and commissioners of digital health technologies.
NICE (National Institute for Health and Care Excellence)

The Topol review

A key independent review on the preparation of the healthcare workforce for delivering the digital future. Expert opinion from both the UK and abroad was collated to explore leveraging digital technology for use in a modern health service.

Health Education England (HEE)

The Goldacre Review

Better, Broader, Safer: Using Health Data for Research and Analysis is a review that explores the potential of NHS data for researchers, innovators and commissioners whilst maintaining the privacy and security of patients data. The report examines the technical and strategic blockers for the use of this data.

Department of Health and Social Care

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