Fellowship in Clinical AI
NHS Digital Academy Programme

NHS Fellowship in Clinical AI

Clinical AI Curriculum 2024

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Contents

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About Us

The faculty for NHS Fellowship in Clinical AI is based in the Clinical Scientific Computing department (https://gstt-csc.github.io/team.html) of Guy's and St Thomas' NHS Foundation Trust. We have deep practical experience in the full life cycle of clinical AI tools in the NHS. We are supported by NHS Digital Academy.

1. Introduction

It is vital for the UK's place as a global AI superpower to implement training pathways for the NHS frontline workforce to gain expertise in clinical AI. This document describes such a pathway.

Artificial Intelligence (AI) technologies will provide tools to improve diagnosis and care across many patient pathways. The effective use of AI within the NHS requires not only AI experts, but also clinicians with AI expertise to act as the bridge to clinical insights and implementation. The clinician is increasingly important in the development and evaluation of AI technologies, with at least 9 distinct roles identified[1]. Internationally, there are initiatives to embed artificial intelligence training within medical training[2].

Mainstream academic routes to AI expertise are not designed to be integrated with clinical work or training in the UK. These routes deter trainees with high up-front costs and interruptions to clinical training. Furthermore, most routes lack curricula relevant to *clinical* AI and the application of AI technology in live clinical workflows. Therefore, there is an unfulfilled need for a route to clinical AI expertise that is integrated within existing clinical training. This need was explicitly highlighted in *The Topol Review*[3]:

"*The NHS should create or increase the numbers of* ***clinician****, scientist, technologist and knowledge specialist posts with* ***dedicated, accredited time,*** *with the opportunity of working in partnership with academia and/or the health tech industry to design, implement and use digital,* ***Artificial Intelligence*** *and robotics technologies."*

-Recommendation *DM4/AIR5* from the Digital Medicine and AI & Robotics Panels.

[1] Scheek, D., Mehrizi, M.H.R. and Ranschaert, E., 2021. Radiologists in the loop: the roles of radiologists in the development of AI applications. *European radiology*, pp.1-9.

[2] Wiggins, W.F., Caton, M.T., Magudia, K., Glomski, S.H.A., George, E., Rosenthal, M.H., Gaviola, G.C. and Andriole, K.P., 2020. Preparing radiologists to lead in the era of artificial intelligence: designing and implementing a focused data science pathway for senior radiology residents. Radiology: Artificial Intelligence, 2(6), p.e200057.

[3] Topol, E., 2019. The Topol Review. *Preparing the Healthcare Workforce to Deliver the Digital Future*, pp.1-48.

2. Purpose

This document specifies a curriculum for clinicians to gain expertise in clinical artificial intelligence. It is designed to be an enduring curriculum for NHS frontline workers to develop expertise in clinical AI alongside their clinical roles.

This curriculum specifies the educational framework for the **NHS Fellowship in Clinical Artificial Intelligence** designed by Guy's and St Thomas's NHS Foundation Trust and supported by NHS Digital Academy. In this fellowship, the fellows are embedded in a clinical AI team at an NHS site. Fellows directly develop, deploy, and evaluate clinical AI models. They will gain AI expertise through immersive project work, didactic and self-paced learning activities, and applied research.

The curriculum is aligned to key educational frameworks including:

- Health Education England's *A Health and Care Digital Capabilities Framework*[4]*,*
- NHS AI lab's *Developing healthcare workers' confidence in AI*[5]
- Faculty of Clinical Informatics' *Core Capability Framework*[6]
- NHS Digital Transformation's *Artificial Intelligence (AI) and Digital Healthcare Technologies Capability framework*[7]

[4] Health Education England, 2018. *A Health and Care Digital Capabilities Framework.*
[5] NHS AI Lab & Health Education England, 2022: *Developing healthcare workers' confidence in AI Report 2 of 2*
[6] Faculty of Clinical Informatics, 2020: *Core Competency Framework*
https://www.bcs.org/media/tfblc4ny/fcicorecompetencyframeworkreport.pdf
[7] NHS Digital Transformation, 2023*: Artificial Intelligence (AI) and Digital Healthcare Technologies Capability framework. https://digital-transformation.hee.nhs.uk/building-a-digital-workforce/dart-ed/horizon-scanning/ai-and-digital-healthcare-technologies*

3. Learning Content

The learning content of this curriculum is illustrated below in two different formats:

- In *Figure 1* below, the delivery methods are mapped according to the relevant stage in the AI life cycle.
- In *Table 1* below, learning objectives are listed along with specific resources relevant to each learning objective.

The delivery methods are:

1. Immersive project in clinical AI
    - Fellows work under the oversight of a supervisor in an NHS site with expertise in clinical AI. This project is a primary focus of the fellowship year and enables the fellow to develop skills in clinical AI deployment which can only be gained through experiential learning. There may be opportunities for publication and research. Projects are proposed by supervisors and approved by the faculty if suitable for the learning objectives of the curriculum. The fellow's supervisor also has additional responsibilities as per Section 5 (*Supervision and Development*) below.
2. Small group workshops
    - Fellows have a bespoke programme of interactive small group masterclass workshops occurring monthly. These workshops are delivered by invited experts in various domains of clinical AI. The topics of discussion are designed to complement and extend beyond the didactic and self-directed elements of the curriculum.
3. E-learning
    - Fellows are enrolled in an established AI and machine learning course, the KCL Innovation Scholars Programme. They will complete didactic modules on 'Demystifying AI', "Python- Software Carpentry", and "Applied AI".
    - Fellows are provided a subscription to an online education platform for the duration of the fellowship, allowing unlimited access to pre-recorded lectures and interactive exercises on statistics, machine learning and software development. Assignments and deadlines for progress are managed by the faculty to prompt engagement with the resource.
4. Networking
    - It is increasingly recognised that opportunities for meaningful professional networking including through on-site workshops, formal mentorship opportunities, peer learning, site visits to centres of clinical AI excellence, alumni events, and pastoral sessions with the faculty are an integral part of the educational delivery.

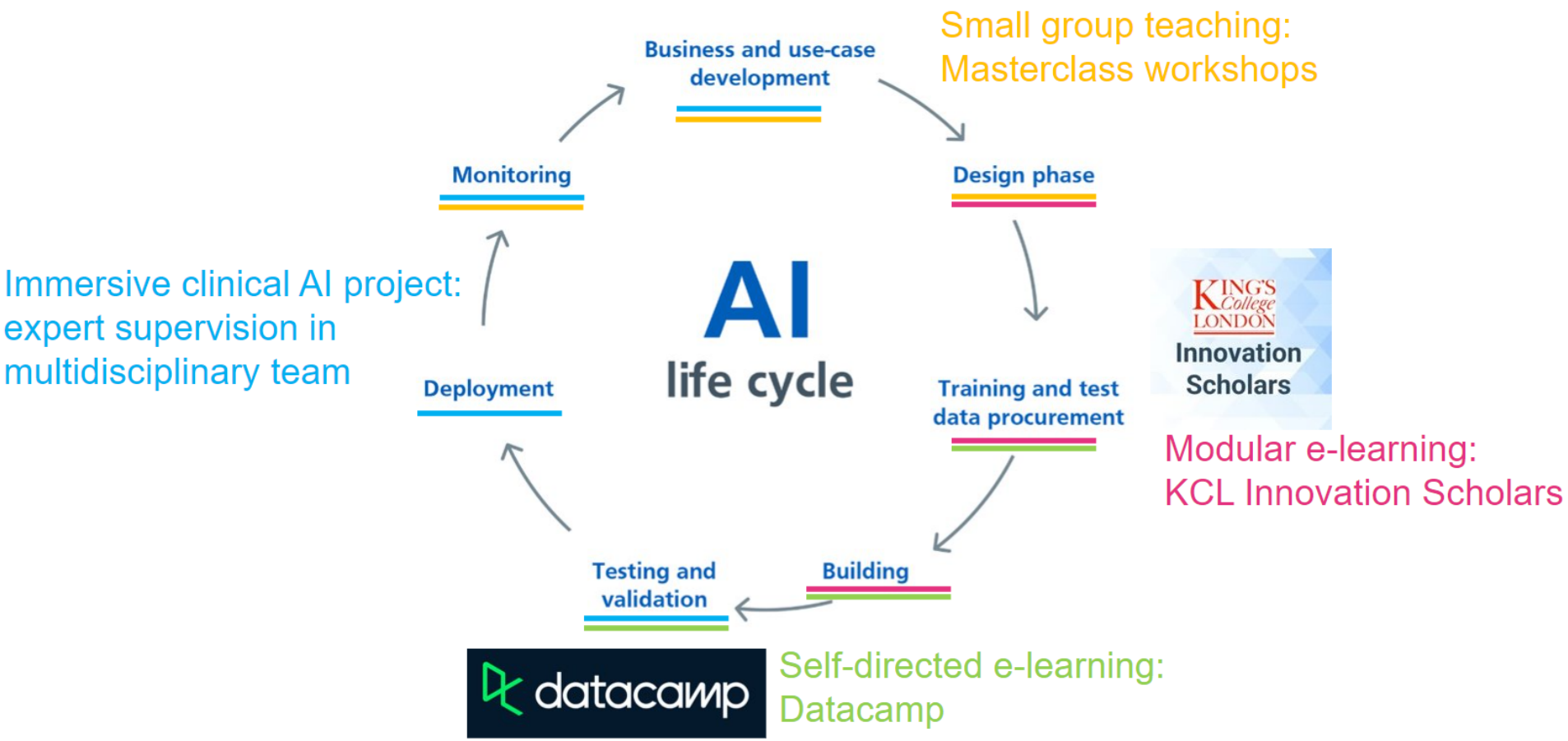

Figure 1. Learning content of the Clinical AI Curriculum as mapped onto the life cycle of AI (adapted from NHSX). The full scope of the life cycle is encompassed by the 4 delivery methods of immersive clinical project work, small group teaching, large group teaching, and self-directed learning.

Curriculum Theme	Resources	HEE Digital Literacies domains[4]	FCI Core Competency Framework[6]
AI fundamentals	Datacamp e-learning Innovation Scholars AI Project Workshops	2a: The ability to use digital technologies and tools for personal learning and professional development 3a: The ability to find, manage, organise, store and share digital information, data and content 4c: The ability to use digital technologies to support or create new ideas, methods, solutions and decisions	3.1 Analytical Methodologies and Applications 3.2 Data Sources and Characteristics 3.3 Data Structure, Standards, and Linkage 3.4 Data Management 3.6 Data Visualisation
Regulation & standards	AI Project Workshops	3b: The ability to understand and act upon appropriate guidelines, protocols, regulations and safeguards in the use of differing media, information, data and content to meet legal, ethical, cultural and security rules, requirements and expectations when working with personal, public, professional and/or confidential information, data and content 3d: The ability to understand and adhere to digital copyright, intellectual property and privacy rules and regulations	1.2 Clinical Governance 2.3 Selecting and Procuring Information Systems and/or Technology 2.6 Data security and Cyber Security 3.5 Information Governance, Accessibility and Ethics
Validation & evaluation	AI Project Workshops Innovation Scholars	3c: The ability to critically analyse, evaluate and/or interpret information, data, content and their sources 4a: The ability to create new digital resources and/or curate existing ones working individually or in collaboration with others 4b: The ability to use devices, technologies, techniques and applications in research, quality improvement, audit and scholarly activities 4e: The ability to lead on and champion the effective, appropriate, creative and innovative use of digital technologies in research, scholarship and other activities.	1.7 Scientific and Research Skills 2.7 Maintenance and Support for Healthcare Information Systems 2.8 Evaluation of Information Systems 4.1 Quality Improvement and Clinical Safety 4.6 Evaluation 5.1 Evidence-based Practice 6.4 Project Leadership
Integration & systems impact	AI Project Workshops Innovation Scholars	3d: The ability to work with and champion the effective, secure, appropriate and innovative use of information, data and content in order to solve problems, make decisions and to achieve successful outcomes for specific goals and objectives 5c: The ability to resolve technical challenges and problems both individually and with others 5d: The ability to use technical knowledge to problem solve and achieve expected outputs	1.3 Models of Care Delivery 1.4 Health Administration and Services 1.5 Informatics Strategies 1.6 Informatics in Health 2.4 Interoperability and Integration 2.5 System Architecture 4.4 Usability and Design 5.3 Clinical Decision Making and Support
Strategy & culture	AI Project Workshops Networking	1c: The ability to work collaboratively with others using digital technologies and tools to produce shared outcomes to meet shared goals 1d: The ability to participate actively in and across digital networks. 2b: The ability to use a wide range of digital technologies and tools in teaching, coaching, mentoring others 4d: The ability to act as a digital champion or change agent 6a: The ability to develop, promote and safeguard appropriate digital identities that support a positive personal and organisational reputation	2.2 Working and Communicating with Project Stakeholders 4.2 Change Management 4.3 Behaviour Change 4.5 Patient Involvement and Engagement 6.1 Multi-disciplinary and Organisational Working 6.5 Informatics Strategy and Innovation 6.6 Planning

Table 1. Themes of the curriculum mapped to educational resources and alignments to frameworks. The learning content and structure of this programme are adapted from Wiggins *et al.* (2020)[2].

Learning objectives are grouped into themes as follows[8]

AI Fundamentals

Regulation & Standards

Validation & Evaluation

Integration & Systems Impact

Strategy & Culture

[8] Adapted from

- NHS AI Lab & Health Education England, 2022: *Developing healthcare workers' confidence in AI Report 2 of 2*
- NHS Digital Transformation, 2023*: Artificial Intelligence (AI) and Digital Healthcare Technologies Capability framework. https://digital-transformation.hee.nhs.uk/building-a-digital-workforce/dart-ed/horizon-scanning/ai-and-digital-healthcare-technologies*

AI Fundamentals

- Understand and apply different types of AI algorithms for different tasks (e.g. logistic regression, decision trees, support vector machines, random forest, K-means clustering, neural networks, Bayesian approaches)
- Understand data provenance, quality and structure requirements for training AI algorithms, such as synthetic data, metadata, taxonomies, ontologies, and standards.
- Perform data extraction and wrangling (e.g. feature labelling/extraction, dimensionality reduction, normalisation)
- Understand types of training for AI algorithms (e.g. supervised, unsupervised, reinforcement, ensemble, distributed, and federated learning)
- Understand types of languages and frameworks used for the creation and analysis of AI algorithms *(*e.g. Python, R, SQL)
- Understand and apply AI algorithm training and optimisation (e.g. tuning hyper parameters, internal validation, optimal stopping)
- Understand and apply common metrics for AI algorithm performance (e.g. precision, recall, F1 score, Receiver Operator Characteristic)
- Understand AI algorithm validation methods (e.g. hold out method, cross validation)

Regulation & Standards:

- Understand CE/UKCA marking and methods for obtaining certification for different classes of medical device for AI technology
- Understand and apply GDPR to AI technology
- Understand and apply NHS Digital's Clinical Risk Management standards to AI technology (i.e. DCB0129, DCB0160)
- Understand and apply HRA definitions of clinical research and service evaluation as they relate to AI evaluation and implementation, following the appropriate governance for each.
- Understand legal frameworks applying to the use of AI technology in clinical decision making. (e.g. negligence, product liability, consent)

Validation & Evaluation

- Critically appraise the published literature relating to AI algorithms, using established evidence standards where appropriate (e.g. NICE evidence standards framework)
- Understand the process of local AI model validation, including prospective clinical studies (e.g. SPIRIT-AI, CONSORT-AI guidelines)
- Establish and manage post-deployment monitoring, evaluation, and iteration of AI technology, including processes for detecting, reporting, and managing adverse effects or serious incidents related to AI
- Understand, measure, and mitigate potential sources of error and bias in AI algorithms, including circumstances leading to inequitable distributions of patient outcomes (e.g. medical algorithmic audit methodology)

Integration & Systems impact

- Integrate AI technology with existing healthcare IT systems
- Design and re-design clinical workflows to integrate AI technology, applying principles such as interoperability and user-centred design
- Evaluate the impact of AI technology in health economic measures, service efficiency, patient outcomes, workforce, and environment
- Understand how user interactions with AI technology may be affected by human cognitive biases (e.g. automation bias, aversion bias, confirmation bias, rejection bias, and alert fatigue)
- Understand AI failure modes and how these differ from human errors in clinical reasoning and decision making (e.g. outlier detection, adversarial attacks), and how to respond in such circumstances
- Understand the principles and limitations of AI explainability
- Understand the principles and guidelines for AI technology procurement in healthcare

Strategy & Culture:

- Participate in and develop multi-disciplinary teams for the creation and deployment of AI technology
- Collaborate effectively with colleagues in academia and industry
- Understand and apply the principles digital transformation and effective change management
- Establish leadership buy-in and support internal champions for change for AI technology
- Understand the learning and development needs of NHS staff for AI technology
- Understand the needs and expectations of patients and public for the ethical and accessible use of AI through the principles of co-design

5. Activities & Duties

The duration of each NHS Fellowship in Clinical AI is 12 months at 0.4 full time equivalent work pattern (2 days per week). This allows sufficient time for fellows to achieve the learning objectives outlined in Section 3, and to make significant contributions to an immersive project in applied clinical AI (representative project summaries from previous are in Table 2).

Fellows begin the programme with an induction period (shown in Figure 2), during which they work-shadow established team members of their clinical AI team to allow full immersion in the culture and working practices.

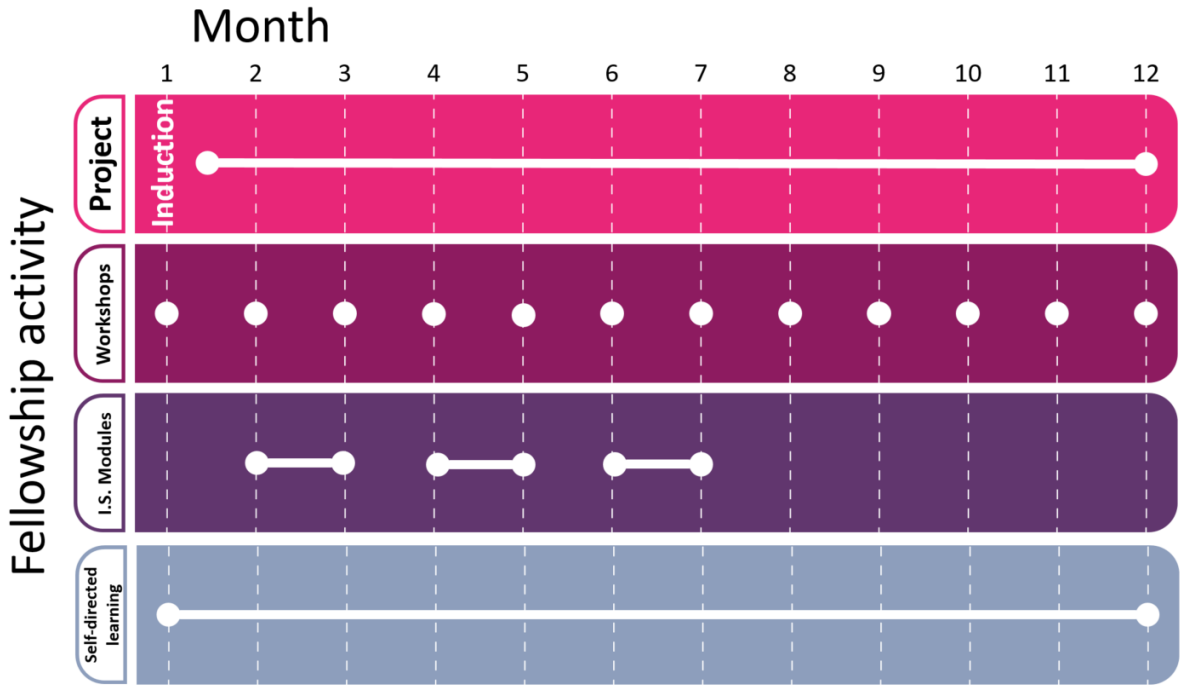

Figure 2. Gantt chart of activities throughout the fellowship year

Duties and responsibilities of fellows in clinical AI include:

1. Work energetically as a member of an agile multidisciplinary team including: AI specialists, medical physicists, IT, health economists, and clinicians.
2. Communicate effectively with key stakeholders in clinical AI including: hospital management, patients, clinicians, regulatory bodies, and technology developers.
3. Curate clinical datasets in accordance with data-protection laws and regulations.
4. Deploy clinical AI in a way that is safe, legal, equitable, and effective.
5. Critically evaluate the performance of clinical AI in hospital workflows.
6. Present scientific findings in clinical AI including clinical trials and quality improvement projects.
7. Understand and develop policies and standards for the regulation of clinical AI.

Table 2. Representative project titles, subject areas, and descriptions of clinical AI projects from previous cohorts

Project	Subject	Description
AI autosegmentation in radiotherapy	Clinical Oncology	Artificial Intelligence automated segmentation algorithms have been touted as tools that can save time and reduce some of that inter/intra-observer variability. The purpose of this application is to expand the deployment and development of AI autosegmentation to tumour sites (female pelvis, upper abdomen thorax, brain) through validation and implementation/deployment of the 'AutoSegCT' autocontouring tool.
AI-based software evaluation in digital pathology diagnostics	Pathology	We are currently validating a proprietary lymph node pathology AI technology with over 1,000 digitised slides, along with specialist breast pathologists to establish the ground truth. This aims to increase efficiency through a reduction in reviewing time per image and an improvement in slide interpretation (including increased sensitivity in detecting micrometastasis) when diagnosing metastatic disease. This project will provide the fellow the opportunity to experience testing, evaluation, implementation and potential deployment of a pathology AI technology as an AI-assisted diagnostic tool into routine practice.
AI-assisted occult scaphoid fracture diagnosis	Clinical Radiology	An AI tool to aid clinical diagnosis of occult carpal fractures using X-rays would increase diagnostic sensitivity in areas and situations where MRI is not available. The fellow will have an opportunity to have participate in model design, help with data cleaning and enrichment, learn about model building and hold a key role in validation, deployment and post-deployment feedback and performance collection and analysis.
Clinical validation, regulatory clearance, and deployment of an AI system in ophthalmology	Ophthalmology	We use an AI system designed to diagnose and triage patients with macular diseases via retinal optical coherence tomography (OCT) scans, using deep learning. This involved a landmark NHS-industry collaboration (Moorfields-Google DeepMind). In an initial proof-of-concept study, it was shown to have performance on par with world-leading ophthalmologists for the assessment of macular disease. The fellow will play a central role in providing the clinical validation required for regulatory clearance. This will involve a mixture between retrospective and prospective ("silent mode") clinical studies at Moorfields Eye Hospital and with international collaborators, and medical algorithmic audit.
Remote Health Monitoring Programme – Digitally enabled neighbourhoods (BRAVE-AI)	Community Care	The focus is an AI based risk assessment tool helps health professionals identify individuals at risk of unplanned hospital admission in the next year. Those individuals identified can then be invited to take part in a holistic assessment so that local, integrated neighbourhood teams of health and care professionals (nurses, pharmacists, therapists, health coaches, social prescribers, and doctors) can work together to develop a personalised care and support plan, based on what matters to the individual. This use of AI will be investigated in its support to establish confidence in benefits which are expressed in ways so that they are recognised by citizens and engaging their support for a shift in behaviours – their own health and care, and contribution to community support and the financial analysis/model that will be required in respect of the upstream interventions, prevention and new models of care; multi-disciplinary and integrated care through a team-of-teams supported by integrated/place based budgets.

6. Supervision & Development

A clinical AI expert is appointed as the AI supervisor for each fellow. The supervisor facilitates senior supervision of the fellow (at least 1hr per week) during the fellowship to discuss their personal development plan, project progress, and troubleshooting. Tools for the documentation of supervision include templates for: an induction meeting, a midpoint review, and end of programme appraisal. The supervisor will provide trainee feedback during the fellowship *ad hoc*, and in writing in the aforementioned formally documented supervision meetings.

On starting the fellowship, fellows complete a personal development plan (PDP) to list their specific goals and describe how these are aligned with their clinical training and broader career aspirations. There are many different roles within the clinical AI development cycle, and fellows should identify specific learning objectives (Section 3) to focus on during the fellowship. Fellows may use the SWOT tool (*Figure 3*) to identify and anticipate their training needs during the fellowship and discuss these with their supervisor.

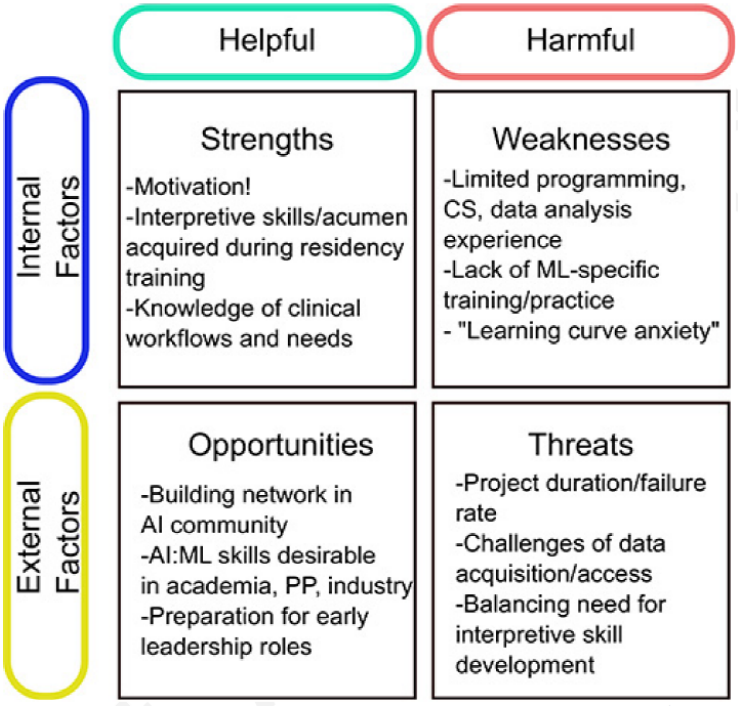

Figure 3. Example of a completed SWOT (Strengths, Weaknesses, Opportunities, Threats) tool for a fellow in a clinical AI fellowship. From Wiggins *et al.* (2020)[2].

Trainees should maintain a portfolio of their activities during the fellowship to demonstrate progression towards objectives listed in their personal development plan. The portfolio should include but is not limited to: record of learning, personal reflections, certificates, awards, posters, publications, presentations, and code repository. This portfolio will contribute evidence to the supervisor's reports.