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# Deloitte AI Institute

# AI and computing in Oncology

**April 2022**

# Agenda

**Scope**

**Patient impacts**

**Technical applications**

**Oncology focuses**

**Barriers and recommendations**

# Application of AI in Life Sciences and Health

**Artificial Intelligence is creating an impact in many sectors and some of the most important areas it's likely to contribute significantly are life sciences and health. It is already enabling and is likely to further accelerate drug discovery, better diagnostics, patient treatment and care amongst a host of other use cases within these sectors.**

Perhaps one therapeutic area which will immensely benefit from the application of AI is Oncology. In a recent paper published by British Journal of Cancer on Nature.com[1], the authors point out how AI and high performance computing is already helping handle large amounts of data for multi-omics analyses and enabling new approaches to cancer detection, treatment and management.

Over the last year, the Deloitte AI Institute has been collaborating with Arjuna Therapeutics, an emerging biotechnology company to build an AI-driven engine on Cloud for accelerating Biomarker (Drug target) discovery in Solid Cancers[2]. As part of our initiate towards driving Precision Medicine for similar life sciences companies, we have been developing an integrated multi-omics infrastructure for running AI/ML pipelines on merged drug sensitivity, genetics, genomics and proteomics datasets; specifically towards use-cases around Biomarker target discovery for various therapies including Nano-medicine.

Many similar initiatives across the life sciences space show us that the applications of AI within Oncology are developing at perhaps a much faster rate than initially thought.

As this trend becomes a concrete reality for the life sciences and health sectors, it is imperative for leaders and decision makers to have a good understanding of how AI can be applied in the context of oncology.

This brief dossier has been borne out of the above understanding and need and is our little attempt to shed light on how AI applied to this therapeutic area, provide some examples of technology providers and summarise key challenges to watch out for life sciences and health companies as they decide to utilize AI.

1. Artificial intelligence in oncology: current applications and future perspectives (nature.com)
2. Cloud AI enabled analysis for cancer treatment development | Deloitte UK

# Scope
## AI tools and methodologies

### 01
### Supervised learning

- Classifies data into defined categories
- Requires significant domain expertise to classify and validate
- Neural networks are effective for high-dimensional analysis of unstructured data such as image classification

### 02
### Unsupervised learning

- Seeks to find underlying structures in data without a specific target outcome
- K-means clustering can identify patient profiles for a certain disease type
- Core role in is exploratory data analysis

### 03
### Reinforcement learning

- Aims to teach an AI agent to take optimised actions to maximise a reward function
- Requires creation of a synthetic model environment
- Has been used with quantum computers to optimise clinical radiotherapy dose decisions for lung cancer

# Patient impacts
## Patient journey

**How AI impacts patients across the pathway from at-risk to remission:**

### 01
### Pre-screening

- Stronger identification of risk factors
- Better selection of at-risk individuals for screening
- Earlier detection of risk factors

### 02
### Diagnosis

- Better accessibility for diagnosis
- Reduced risk of false-negative diagnosis
- Faster and earlier diagnosis

### 03
### Active treatment

- Stronger identification of treatment response
- Earlier identification of treatment response
- Personalised treatment

### 04
### Post-treatment

- Effective follow-up screening
- Remote ongoing patient monitoring through wearable devices

**Paige**

Paige uses AI technology to support prostate and breast cancer diagnosis from biopsy samples. Paige Prostate has been FDA approved for in vitro diagnosis, proven to increase diagnostic accuracy.

**Vinehealth**

Vinehealth is a digital health platform that aims to improve the quality of life and outcomes of cancer patients. Using a combination of behavioural science and AI, it enables patients to track their symptoms, manage their medications and understand their care. VinehealthPRO® can also deliver the crucial data needed to represent the voice of patients in healthcare delivery and drug development. This enable clinicians and researchers to truly understand how patients are responding to treatment in order to transform the delivery of cancer services.

# Public health

## How AI impacts the healthcare delivery model, and improves wider effectiveness and efficiency

AI enables patients to interact further down the healthcare delivery touchpoint cascade.

*Emergency and hospital services have more stretched demand*

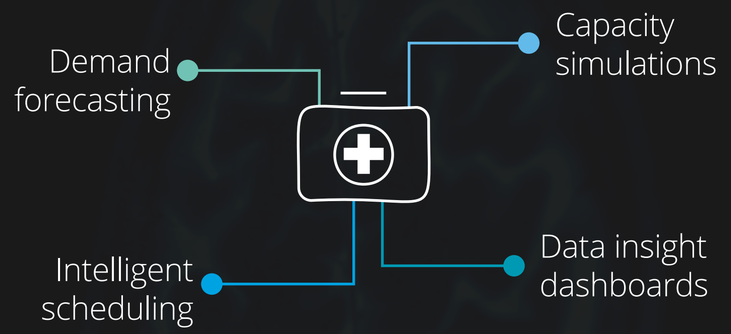
**At-home care**
*Monitoring, telehealth, home visits*

**Primary care**
*GPs, diagnostic screening*

**Acute care**
*Specialised staff, emergency services*

*By providing same interaction lower on the cascade, health services can better handle demand*

AI-powered tools can improve healthcare service efficiency by supporting optimised planning and scheduling.




**Lifelight**

Lifelight provides remote healthcare monitoring through smartphones. Allows more to be achieved through remote appointments, enables more frequent clinical observations, and reduces observation time.

**Kortical**

Kortical provides AI demand planning and logistics optimisation for the NHS. Case study in blood transport logistics reduced platelet expiry by 54% and removed ad-hoc transport entirely.

# Technical application
## Four key pillars

**AI is applied across four key pillars**

### 01
### Predictive modelling

- Analysis of historical diagnosis and treatment data to help doctors provide better predictions
- Population health data enables better targeted screening, and discovery of underlying cancer causes
- Cancer development monitoring during treatment to make faster choices

### 02
### Diagnostics

- Use of biopsy samples or images for detecting cancer earlier
- Reducing risk of cancer misdiagnosis by providing AI second opinion
- Allowing initial screening to be conducted with less reliance on specialists
- Supporting precision clinical treatment selections

### 03
### Image analysis

- Automated tools for detecting cancer cells in photographs, radiographs, and CT scans
- Supports early diagnosis for discovery of cancer
- Supports treatment through tracking cancer growth or decline

### 04
### Drug development

- Augments and enhances capabilities of research scientists
- Aims to improve drug discovery, biological modelling
- Aims to shorten trial pipeline, allowing drugs to market faster

# Technical application
## Predictive modelling

### 01
### Technologies

**Traditional:**
- Prognostic and predictive models
- Logistic / Cox regression analysis

**Novel:**
- Unsupervised learning
- KNN cluster analysis

### 02
### Impacts

- Improved treatment selection
- Better diagnostic triage, selecting those most at risk
- More accurate, personalised models for health and life insurance

### 03
### Challenges

- Driven by training data, so prone to biases
- Patient outcomes impacted by wider context not captured by EMR data
- Not able to predict outcomes that haven't occurred historically

### 04
### Future

- Algorithms better embed clinical and biological knowledge to drive accuracy
- Allows prediction of outcomes that have not occurred in training data
- Makes use of synthetic training data

MIT CSAIL

**Mirai**

Mirai is an algorithm developed by MIT CSAIL predicting cancer risk using a patient's mammogram, currently being used at Massachusetts General Hospital. Mirai was significantly more accurate than prior methods in predicting cancer risk and identifying high-risk groups.

$H_2O$.ai

**H20.ai**

H2O.ai is a software platform for developing AI solutions, with applications across healthcare and pharmaceuticals. Working with Change Healthcare, Armada Health, and others they have built AI models for predicting hospital readmissions using EMR data and specific patient condition information.

# Technical application
## Diagnostics

**AI tools enable early detection of cancer and inform clinical decisions for treatment selection**

### Detection

- Analysis of biopsies, cytometry data, MRI, and radiology images
- Analysis of slides before a pathologist highlighting areas of interest for them
- Diagnostic quality control to alert discrepancies from pathologist opinion

### Guiding treatment

- Grading cancer development to inform clinical treatment decisions
- Tumour “fingerprinting” to create a personalised treatment strategy
- Creation of a diagnostic report alongside clinical recommendations of approved and investigational drugs

### Diagnostics is core focus for health AI

48%

Of unique AI healthcare products are diagnostic tools[1]

**OncoDNA**

OncoDNA develops biomarker tests to better understand molecular complexity for solid tumours. They can inform the selection of cancer treatment and support the close monitoring of patient response to treatment.

# Technical application
## Image analysis

### Appropriate for AI

- Image classification and analysis is a good fit for machine learning:
- Diagnostic image data is in a standardised digital format, providing highly structured input training data[1]
- General image classification ML models have been developed in other industries, making the technology relatively mature

### Methods

**3D quantitative assessment** (size, shape, texture) **better tracks disease progression,** but typically only linear 1D metrics are used in clinical practice

**19% of AI solutions are trained on algorithmically generated datasets**[1], simulating scenarios that may not have occurred historically

### Cancer screening

Skin, lung, breast cancer detection, characterisation

### Precision diagnosis

Tumour segmentation and grading, radiogenomics

### Treatment optimisation

Prediction of therapy outcome, organs at risk

**First Derm**

First Derm provides an automated skin cancer detection service through mobile app, allowing individuals to test lesions at home quickly. First Derm searches image database for closest matches to advise on potential skin conditions including skin cancers, providing an early screening.

**Kheiron**

Kheiron collaborates with Stanford to assist radiologists in more effectively staging and monitoring treatment response of Non-Hodgkin's Lymphoma and breast cancer through assessment of radiology images and mammography.

1. https://www.nhsx.nhs.uk/media/documents/NHSX_AI_report.pdf

# Technical application
## Drug development

### AI in drug discovery

- Natural language processing (NLP) for medical literature review, recognising patterns at scale for discovery of disease drivers
- Biological mechanism analysis through unsupervised learning, discovering novel biomarkers and disease mechanisms
- Disease subgroup discovery, using unsupervised learning to better stratify trial patients and drive precision medicine
- Representation learning for modelling molecular biology, enabling prediction of new therapies and predict important properties

### AI in clinical trials

- Remote patient monitoring, making use of wearables and digital reporting apps, allows patients to remain engaged while making fewer hospital visits
- Novel endpoint discovery through live analysis of high quality, real-time data, helping to find clinically relevant signals in an automated manner

### Quantum computing

Sample companies using quantum computing for drug development and discovery


**BenevolentAI**

BenevolentAI develops therapeutic target identification tools. They are focusing on mechanisms that contribute to progression and relapse of Glioblastoma.

**Deep Lens**

Deep Lens accelerates oncology clinical trial enrolment, using AI to connect trial sponsors to oncology practices. Biomarkers identify eligible patients, and can drive 300% increases in accrual rates.

# Onocology focuses
## Public health priority areas for AI in oncology

**Key focus for public health is across six cancer types, driven by image analysis applicability and public health impact**

### Key data points

**53%** of cancers in the UK are breast, prostate, lung, or colon cancer, from more than 200 types[1]

**When discovered early, prostate cancer survival rate increases from 49% to 100%[2]**

**25%** of patients visit their GP with skin problems each year, a significant strain on community care resources[3]

**Haematology issues and lung x-ray imagery typically require specialists to analyse, AI can reduce specialist demand**

### Dermatology/skin cancer

SkinVision · FIRST DERM

### Prostate cancer

IBEX · indica labs · APEXQUBIT · Paige

### Breast cancer

Paige · Mia

### Lung cancer

aidence · MIT

### Colon cancer

OncoDNA · xilis

### Haematology

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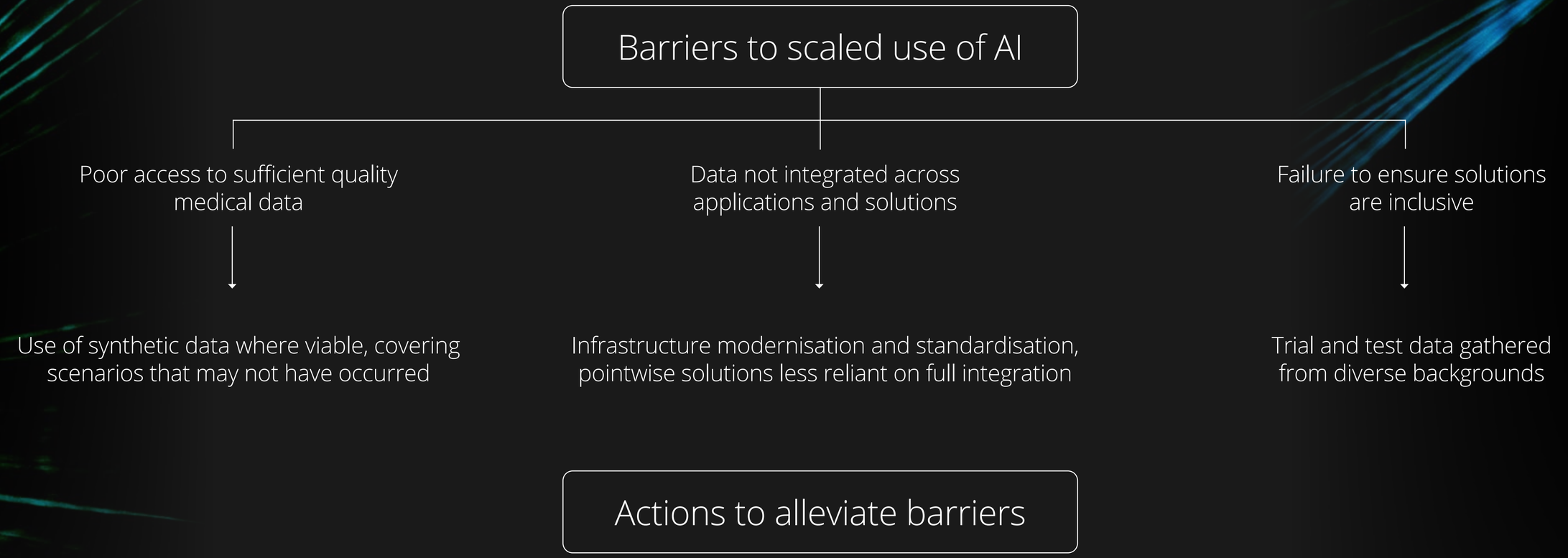
1. cancerresearchuk.org/health-professional/cancer-statistics/incidence/common-cancers-compared
2. cancerresearchuk.org/health-professional/cancer-statistics/statistics-by-cancer-type/prostate-cancer
3. elearning.rcgp.org.uk/mod/book/view.php?id=12891

# Barriers to adoption and recommendations



# Appendix
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Designed and produced by 368 at Deloitte. J30103