



From Data to Decisions

AI in Clinical Research & Precision Medicine

“How can patient data help us make better treatment decisions?”

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Learning objectives

- 1 Explain how AI can support clinical research and patient recruitment.
- 2 Describe how clinical and real-world data can be used for AI-supported analysis.
- 3 Explain precision medicine and the role of biomarkers.
- 4 Understand the basic idea of pharmacogenomics and treatment response.
- 5 Describe how AI can work with clinical text and medical images.
- 6 Recognise why validation, bias, privacy and human oversight matter.



One diagnosis, many patients

A diagnosis tells us something important. It does not tell us everything about an individual patient.

Patient A

Same broad diagnosis
Different genetics
Different treatment history

Patient B

Same broad diagnosis
Different biology
Different response

The question

Can patient-level
information help us choose,
predict or monitor
treatment?

“Should two patients with the same diagnosis always receive exactly the same treatment?”



Genetics



Biology



Treatment history



Where does clinical data come from?

Electronic health records

Diagnoses, clinical notes, medications and procedures

Laboratory results

Blood tests, biomarkers, microbiology and chemistry

Medical imaging

X-ray, CT, MRI, pathology and other images

Molecular data

Genomic variants, expression and other molecular measurements

Clinical trials

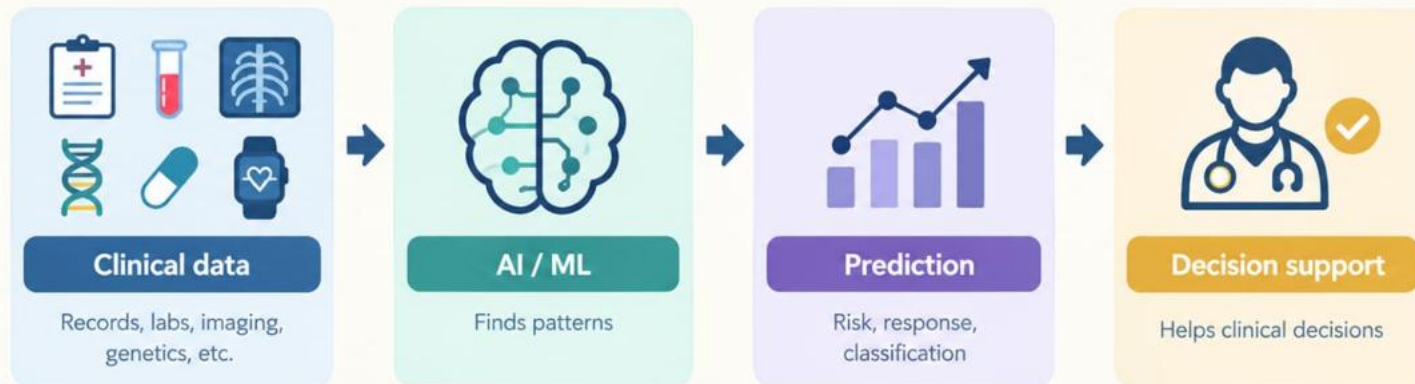
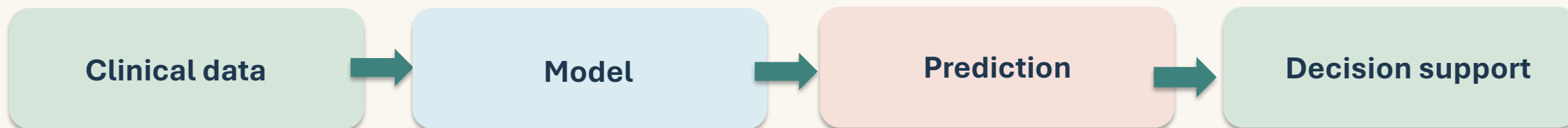
Eligibility, interventions, outcomes and adverse events

Patient-generated data

Questionnaires, wearables and remote monitoring



What does AI do with clinical data?



Examples

Risk prediction •
classification • pattern
detection

The key idea

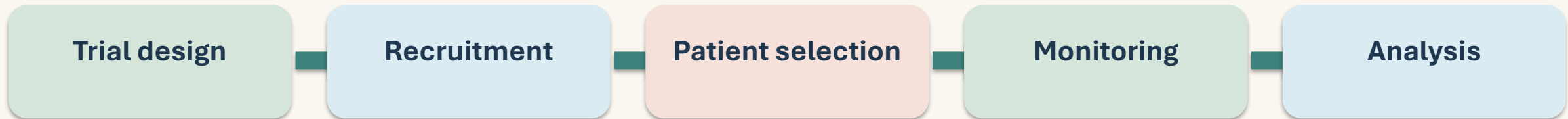
The model learns patterns
for a defined task.

Human role

Interpret the result in the
clinical context.



AI across the clinical research process

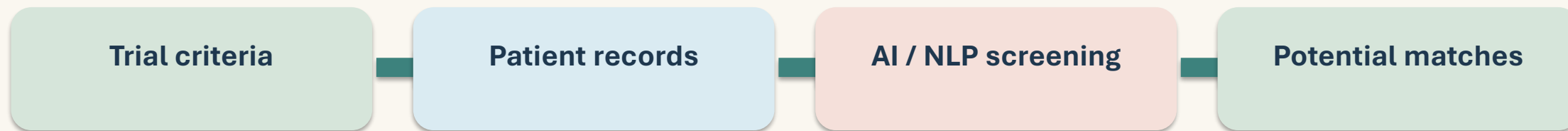


- AI can support different stages, but the task must be clearly defined.
- The right question is not “Can AI do this?” but “What specific problem can AI solve reliably?”

“Where do you think AI could save researchers the most time?”



Finding potential participants for clinical trials



What AI can help with

Searching records, extracting relevant information and flagging potentially eligible patients.

What still has to happen

Eligibility must be confirmed against the study protocol and appropriate research oversight.



Clinical-trial recruitment: useful, but not neutral

Potential benefit

- Faster screening
- Less manual searching
- More systematic matching

Potential problem

- Missing data
- Incorrect extraction
- Uneven representation

The question

Does the model perform well for the population we actually need to recruit?

“If the data used for recruitment are biased, what happens to the study?”



Clinical data: prediction is not the same as evidence

- AI can identify patterns across large datasets.
- It can help predict selected outcomes or risks.
- It can help researchers explore complex relationships.
- But a model output is still a prediction—not automatically a causal explanation.

Keep the distinction clear

Prediction:

“What is likely to happen?”

Causation:

“What causes what?”

Clinical evidence:

“What should we do, based on appropriate evidence?”



What is precision medicine?

Precision medicine uses relevant information about an individual to help tailor prevention, diagnosis or treatment.

Broad approach

Use the same general treatment strategy across a population.

Precision approach

Use meaningful patient differences to inform the treatment decision.

“Precision medicine is not “one treatment for everyone.””



What makes patients different?

Genetics

Inherited and acquired genetic variation

Disease biology

Molecular subtype and biomarkers

Age and organ function

Factors affecting risk and drug handling

Previous treatment

Response, resistance and treatment history

Lifestyle and environment

Factors that may influence health and response

Medication history

Concomitant medicines and previous adverse effects



Biomarkers: clues about disease and treatment

A biomarker is a measurable characteristic that provides information about a biological process, disease or response to treatment.

Diagnostic

Helps identify or characterize a disease.

Prognostic

Provides information about likely outcome or disease course.

Predictive

Helps indicate who is more likely to benefit from a particular treatment.

“The same biomarker can be used for different purposes depending on the clinical question.”



Prognostic vs predictive

PROGNOSTIC

“What is likely to happen?”

Think: disease course or outcome.

PREDICTIVE

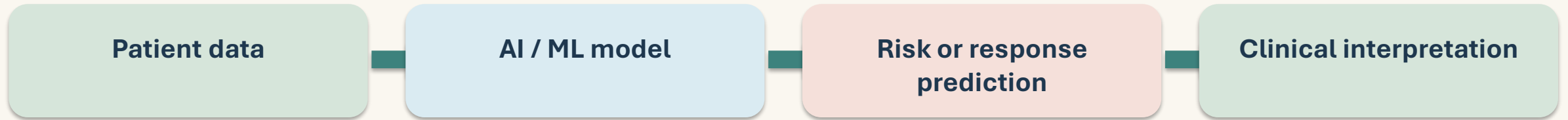
“Which treatment is more likely to work?”

Think: treatment response.

“If a biomarker helps identify patients who are more likely to benefit from Drug A, that is a predictive use.”



Where does AI enter precision medicine?



Possible outputs

Risk score • classification • predicted response

What affects it

Data quality, model choice and population.

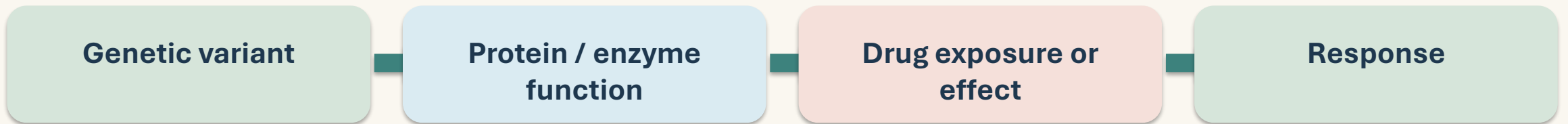
Human role

Interpretation, context and accountability.



Pharmacogenomics: why genetics can affect drug response

Genetic differences can influence drug metabolism, transport or pharmacological response.

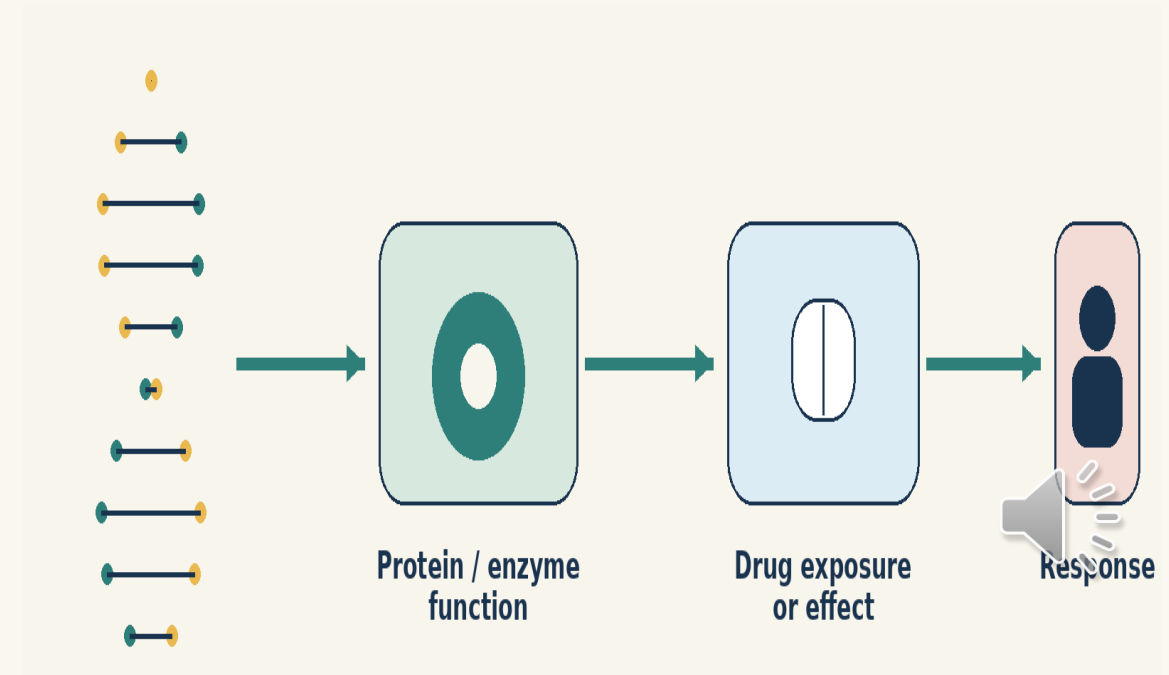


Example

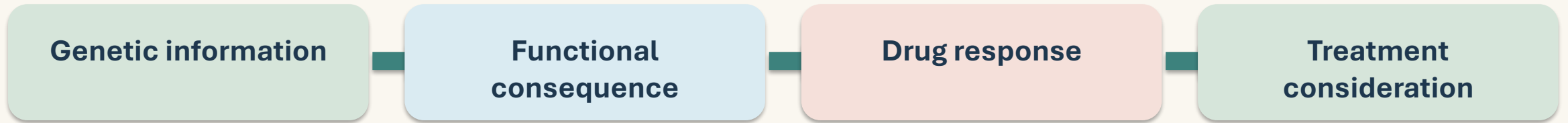
CYP2C19 variation can affect activation of clopidogrel.

Important

Clinical use depends on the specific gene, drug, evidence and relevant guidance.



From genotype to treatment decision



- AI can help integrate genomic information with clinical history and other patient data.
- A model can support a decision; it does not make the clinical decision by itself.

“More data does not automatically mean a better decision.”



Clinical NLP: turning medical text into usable information

Clinical note

“Patient developed a rash two days after starting Drug X.”

NLP extraction

Drug
Symptom
Timing

Structured information

Drug: X
Event: rash
Timing: 2 days after starting

“The goal is to make important information searchable and analyzable.”



Why clinical NLP matters to pharmacy

Medication information

Extract drugs, doses, routes and changes from clinical notes.

Adverse events

Link medicines with symptoms, events and timing.

Literature and evidence

Search and organize large volumes of biomedical text.

“NLP can reduce the burden of finding information—but extraction errors still matter.”



Computer vision in healthcare

Computer vision allows AI models to analyze images for a defined task.

Radiology

X-ray, CT and MRI can be analyzed for selected findings.

Pathology

Models can analyze tissue images and regions of interest.

Other images

Examples include dermatology and ophthalmology.

“An image model may perform one specific task; that is not the same as diagnosing the whole patient.”



What can an AI image model actually do?

Classification

“What is this?”

Assign an image to a category.

Detection

“Where is it?”

Locate a finding or object.

Segmentation

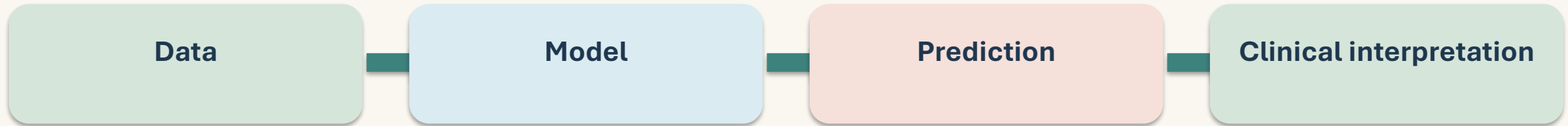
“Which pixels belong to it?”

Outline a region.

“Same image. Different task. Different output.”



AI prediction is not clinical truth



Accuracy

Overall performance can hide important errors.

Calibration

Predicted probabilities should mean what we think they mean.

Generalization

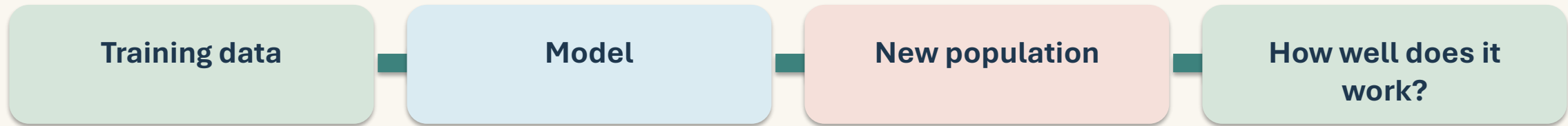
Performance can change in a new population.

Context

Clinical meaning matters.



Bias and generalization



Ask who is represented

Age, sex, ethnicity, disease severity, geography and care setting can matter.

Ask what is missing

A model may learn patterns that reflect the dataset rather than the underlying biology.

What helps

External validation and evaluation across relevant subgroups.



Privacy, governance and patient data

- Protect confidentiality and control access to sensitive information.
- Use appropriate de-identification and data-governance practices.
- Be clear about how data are collected, stored and used.
- Consider consent, accountability and security requirements.
- Remember that better AI does not justify careless data practices.

Discussion

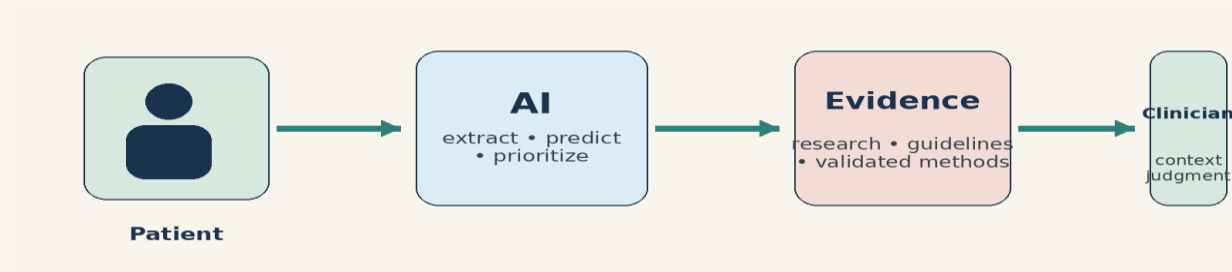
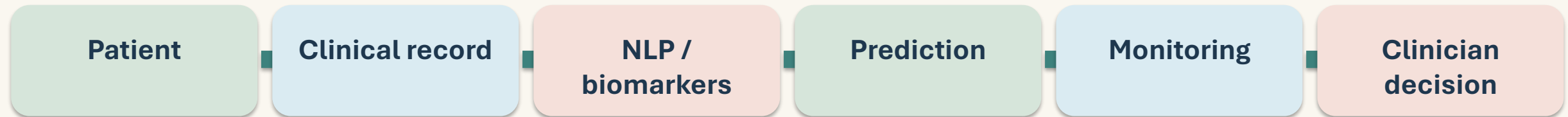
Would you want your medical record to be used to train an AI system?

What safeguards would make you more comfortable?

“The question is not only what AI can do with patient data, but what it should be allowed to do.”



One patient, many AI touchpoints



AI contributes

Pattern recognition, extraction, prioritization and prediction.

Evidence contributes

Validated methods, clinical research and treatment guidelines.

Humans contribute

Context, values, judgment and accountability.



“The goal is not to remove the clinician from the loop.”

Key takeaways

- Clinical data are rich, but they are also messy, incomplete and sensitive.
- AI can extract information, detect patterns and make task-specific predictions.
- Precision medicine uses meaningful differences between patients to inform care.
- Biomarkers and pharmacogenomics can help connect patient characteristics with treatment response.
- Clinical NLP and computer vision extend AI into text and image-based healthcare data.
- AI can support clinical decisions—but it does not replace evidence, clinical judgment or accountability.

“Use AI to make better-informed decisions—not to stop thinking.”

