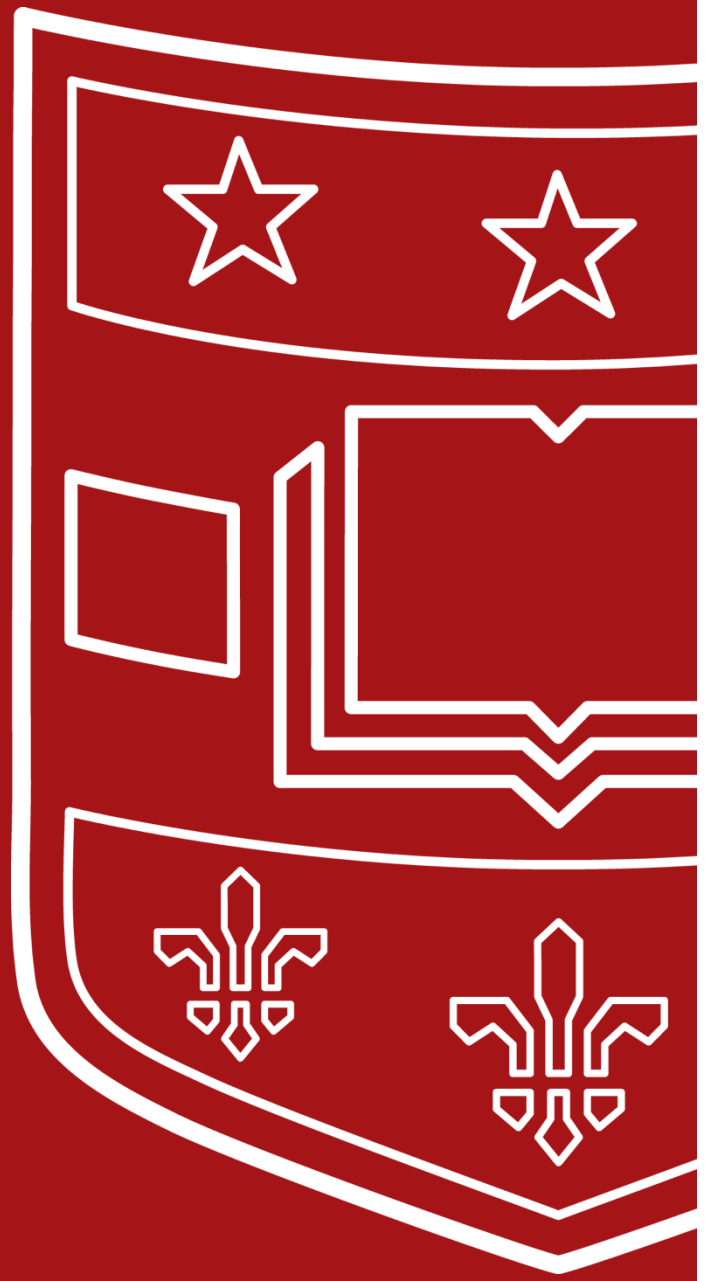
AI Across Medicine

Opportunities for Oncology

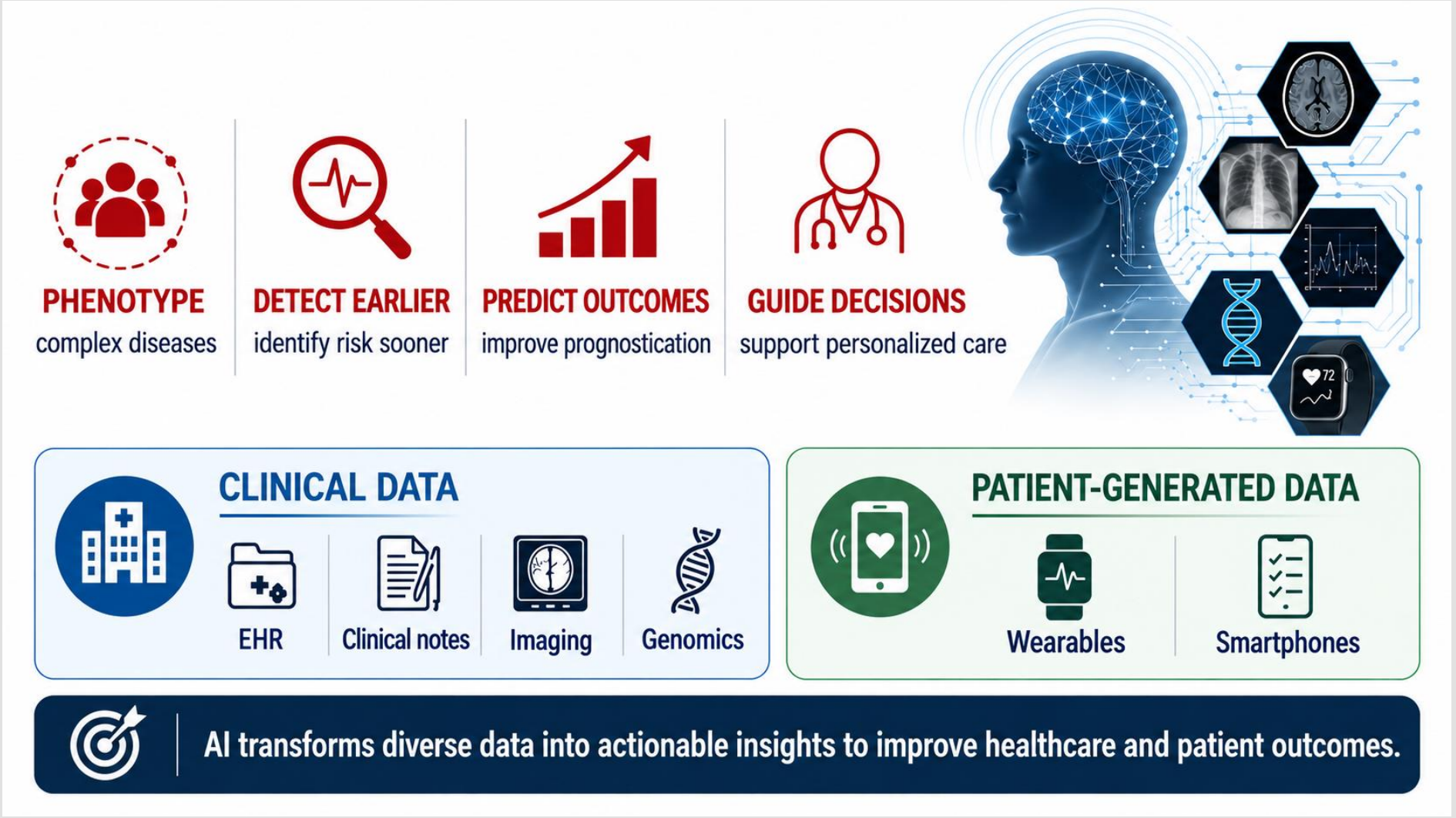
Chenyang Lu
Director, AI for Health Institute
Fullgraf Professor
Computer Science · Anesthesiology · Medicine · Neurosurgery · Psychiatry · Public Health



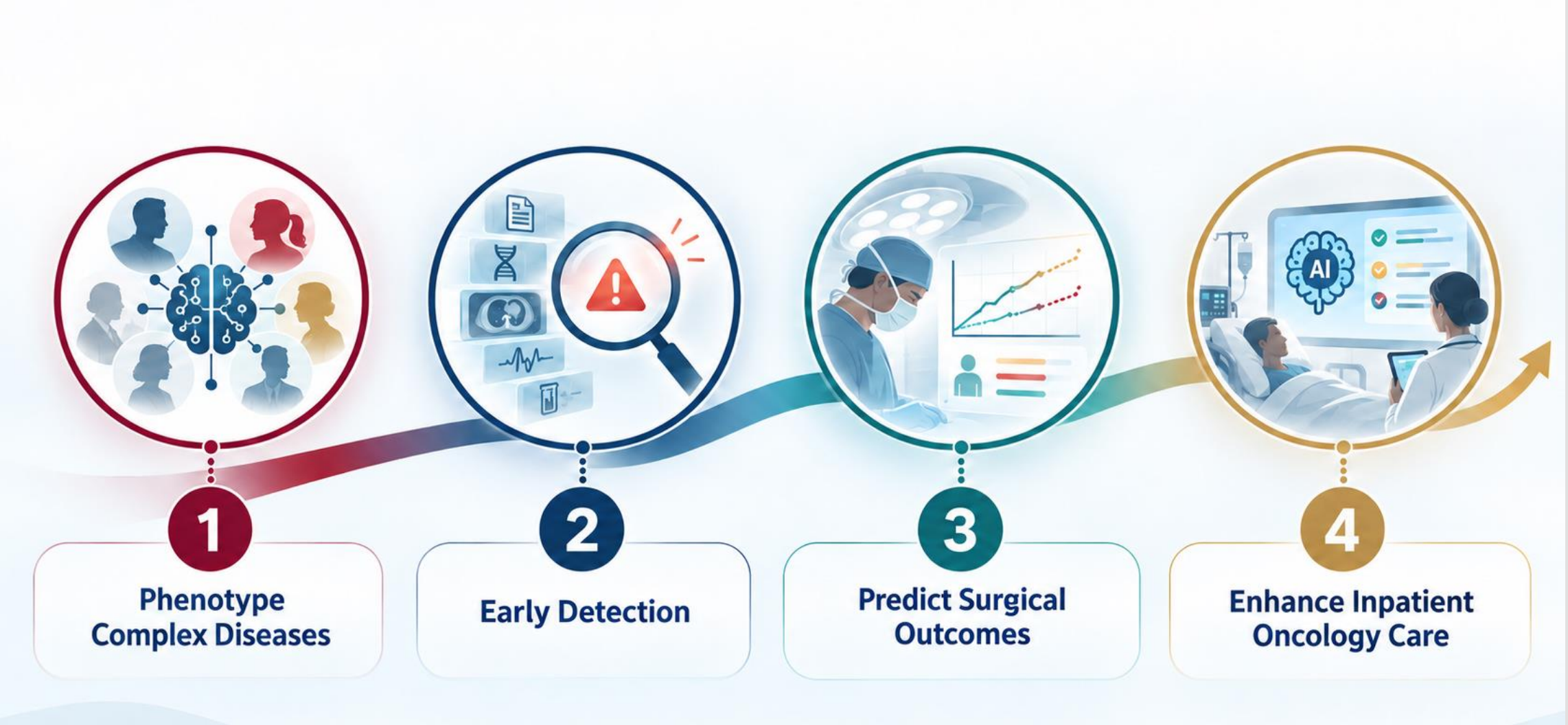
Washington University in St. Louis

Activity ID: 71548

AI for Health



AI Across the Care Continuum

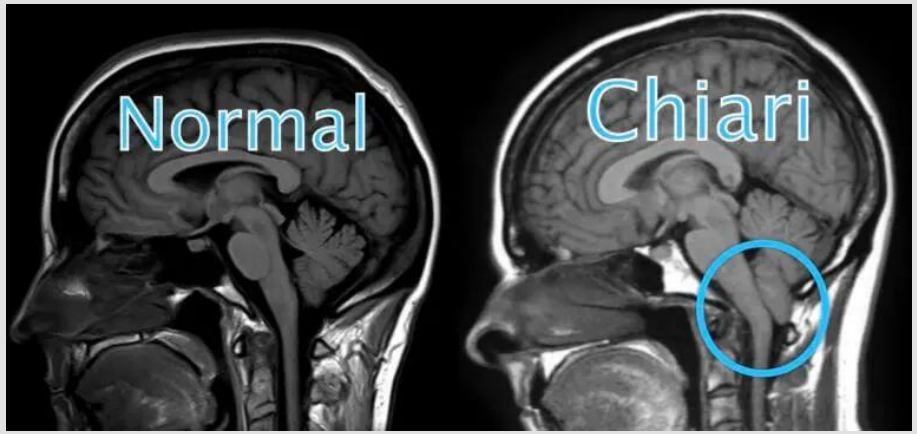


Chiari Malformation Type 1 (CM1)

- CM1 is a **heterogeneous** disease
  - an abnormality in the back of the head where the brain and spinal cord meet
  - ≥5 mm of cerebellar tonsillar ectopia below the foramen magnum on brain MRI scan

- Congenital disease affecting 3.6% of the population

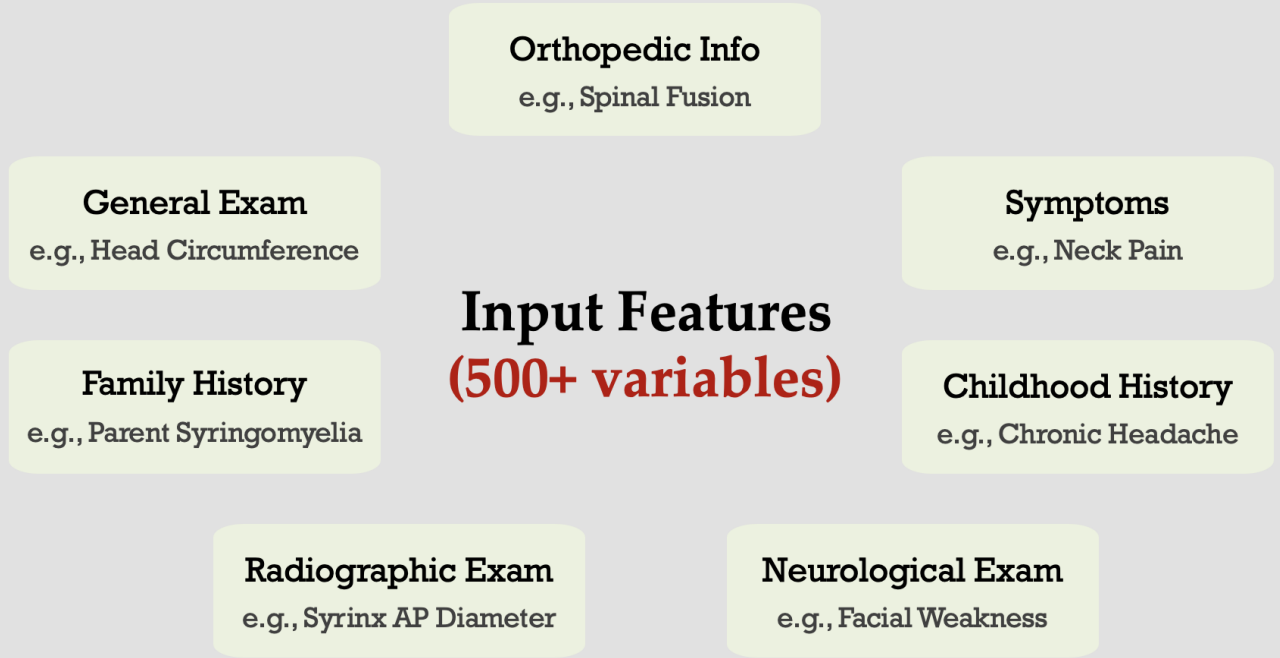
- **Significant differentiation in clinical presentation and natural history**



Phenotype CM1

- CM1 likely reflects multiple clinical phenotypes rather than a single disease entity.
- Goal: Identify **distinct, clinically meaningful** phenotypes

Park Reeves Syringomyelia Research Consortium registry: 1340 patients from 42 medical centers since 2011



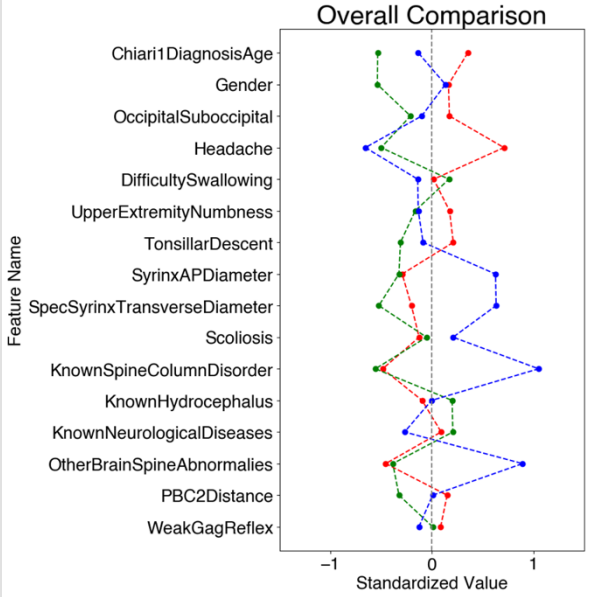
Work with Dave Limbrick, Jacob Greenberg, Sean Gupta (Neurosurgery), Ziqi Xu (CSE)

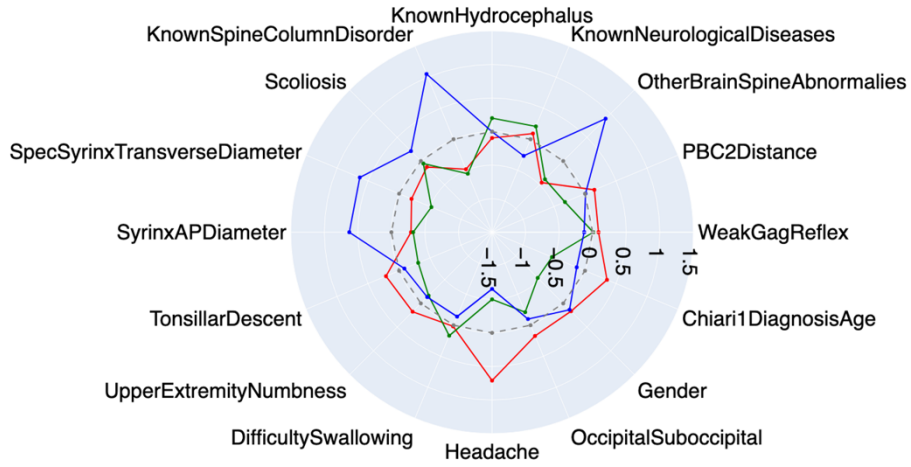
Clustering

- **Identified three distinct clusters**
- **Reproducible across internal/external cohorts**
- **Inform clinical decision-making and management**

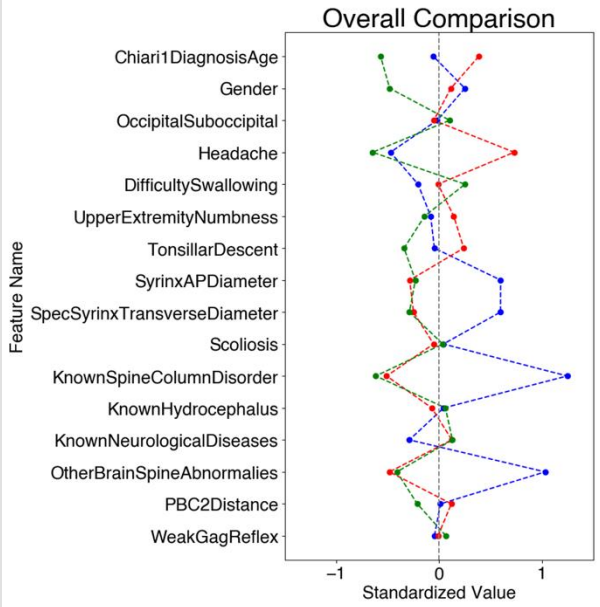
Gupta VP, Xu Z, Greenberg JK, Strahle JM, Haller G, Meehan T, Roberts A, Limbrick DD Jr, Lu C. Using artificial intelligence to identify three presenting phenotypes of Chiari type-1 malformation and syringomyelia. *Neurosurgery*. 2024 Nov 18.

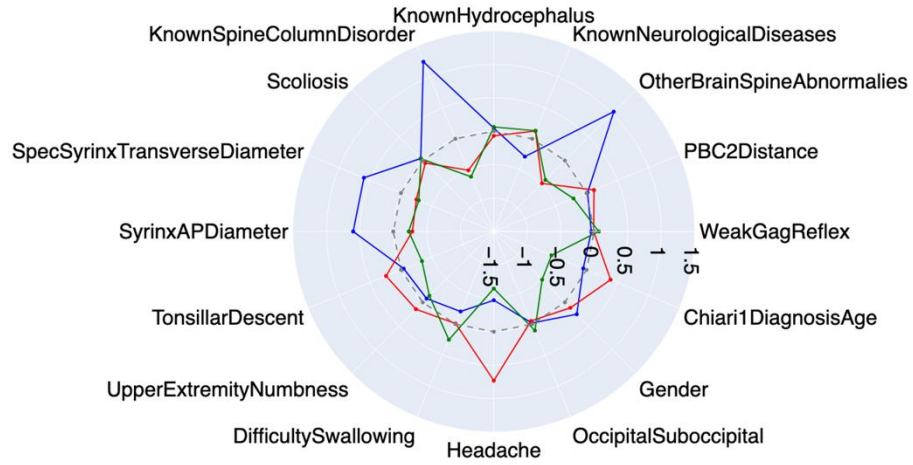
Curve and Radar Plot for Internal Cohort





Curve and Radar Plot for External Cohort





Clinical Implications

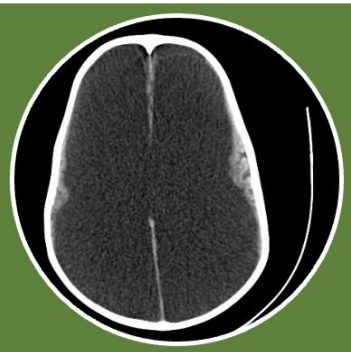
Classic CM1 + syrinx
- Headache-dominant
- Few additional symptoms

Developmental comorbidities
- Few classic CM1 symptoms
- Progression under study

Syrinx and spine related effects
- Early diagnosis → may prevent major surgery



Cluster 1
- Highest diagnosis age
- More likely female
- Presents with HA
- Fewer bulbar symptoms
- Greatest tonsillar descent
- Small syrinxes
- Few other medical issues
- n=277



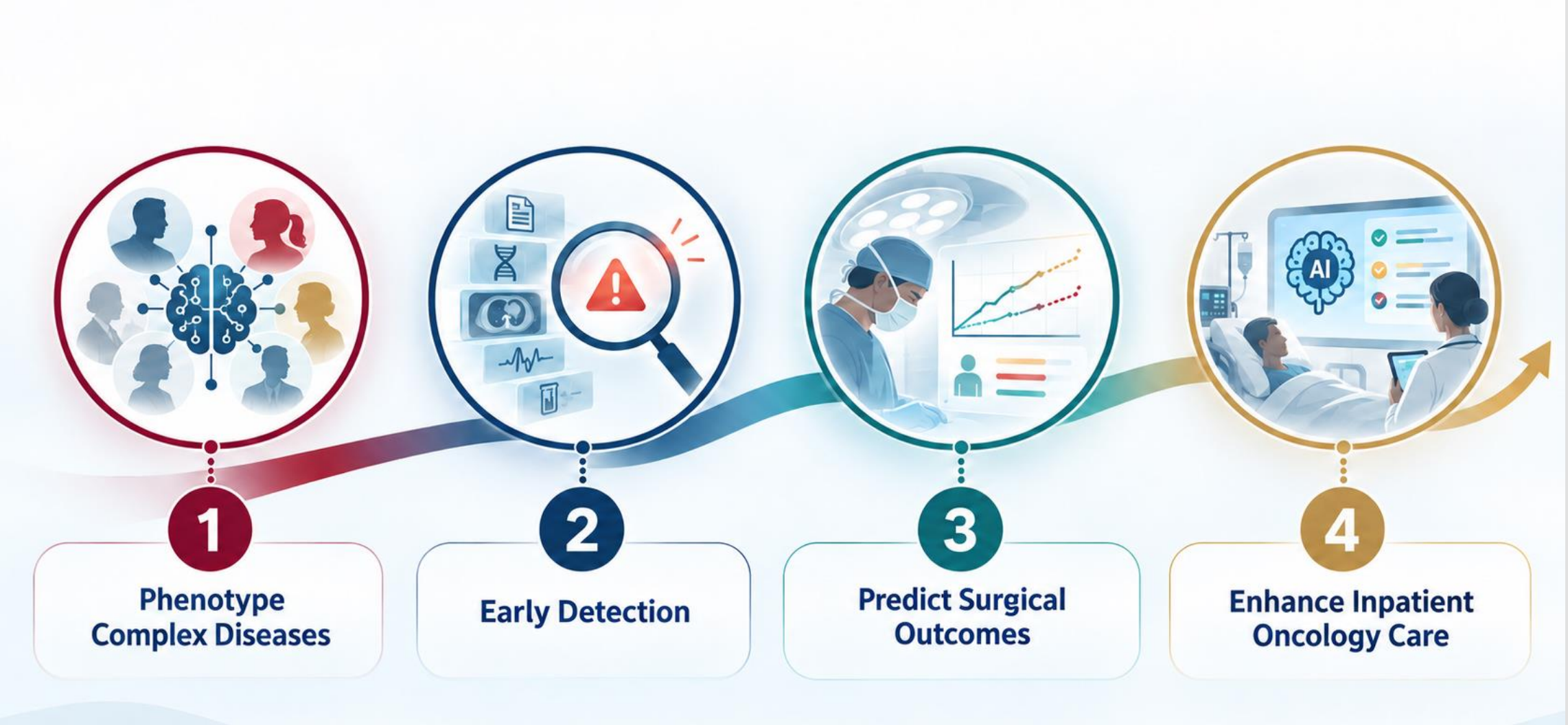
Cluster 2
- Youngest diagnosis age
- Less tonsillar ectopia
- Small syrinxes
- Many newborn issues
- Fewer headaches
- Most hydrocephalus
- Most bulbar symptoms
- n=258



Cluster 3
- Less tonsillar ectopia
- Largest syrinxes
- Most spine disorders
- Most scoliosis
- Most motor deficits
- Fewer headaches
- Fewer bulbar symptoms
- n=187

- Typical radiologic definition is inadequate for heterogeneity of CM1
- Identified clusters potentially assist clinicians direct clinical management

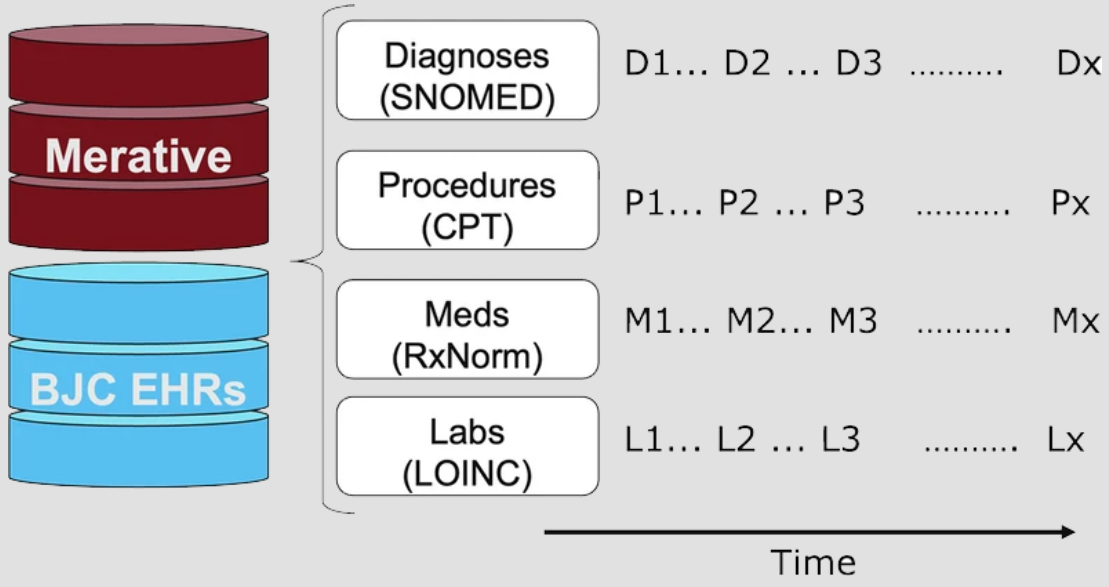
AI Across the Care Continuum



Predict Cervical Spondylotic Myelopathy (CSM)

- CSM is the **leading cause** of spinal cord dysfunction in older adults
- Diagnosis is frequently delayed by **2–6 years** after symptom onset
- Goal: Predict CSM using **longitudinal EHR data** before clinical diagnosis

Data
- Merative MarketScan: ~1.4M patients' longitudinal claims data
- BJC Health: ~500K patients' institutional EHRs



Work with Jacob Greenberg, Salim Yakdan (Neurosurgery), Ben Warner (CSE)

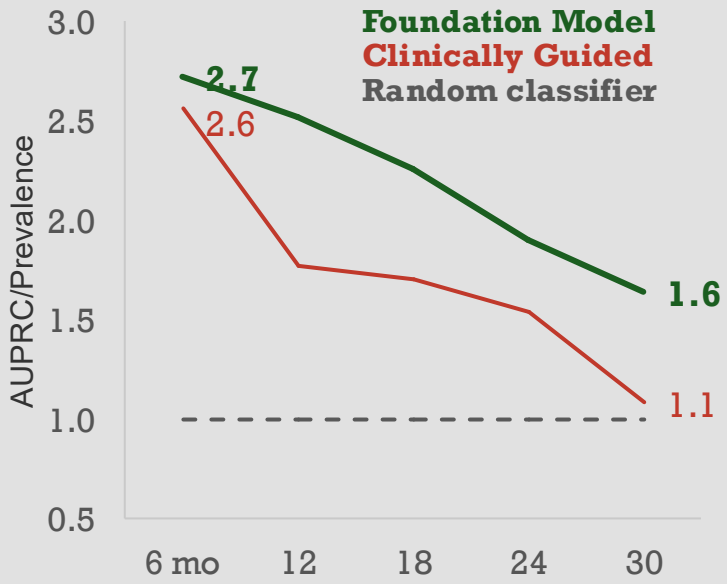
AI-Driven Early Detection of CSM

INTERNAL VALIDATION:
Predictive performance up to 30 months in advance

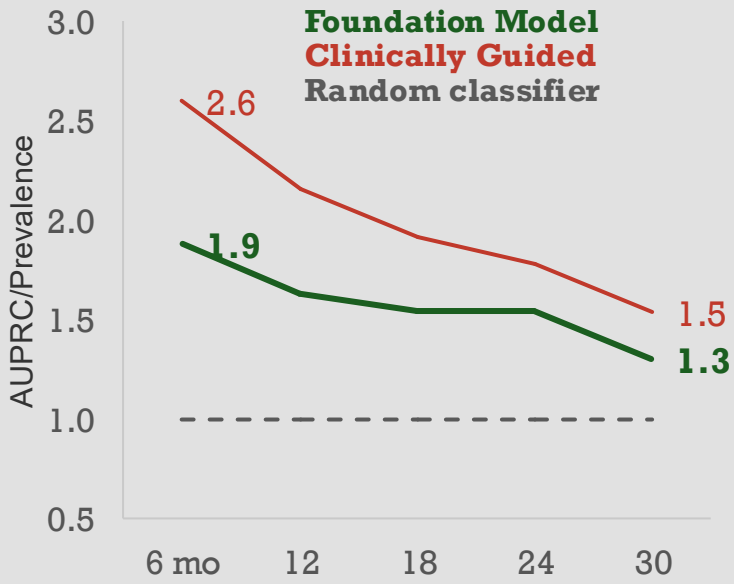
EXTERNAL VALIDATION:
Clinically guided model retains its performance

KEY TAKEAWAY:
Clinical knowledge drives better generalization

Internal Validation (BJC)



External Validation (Merative)

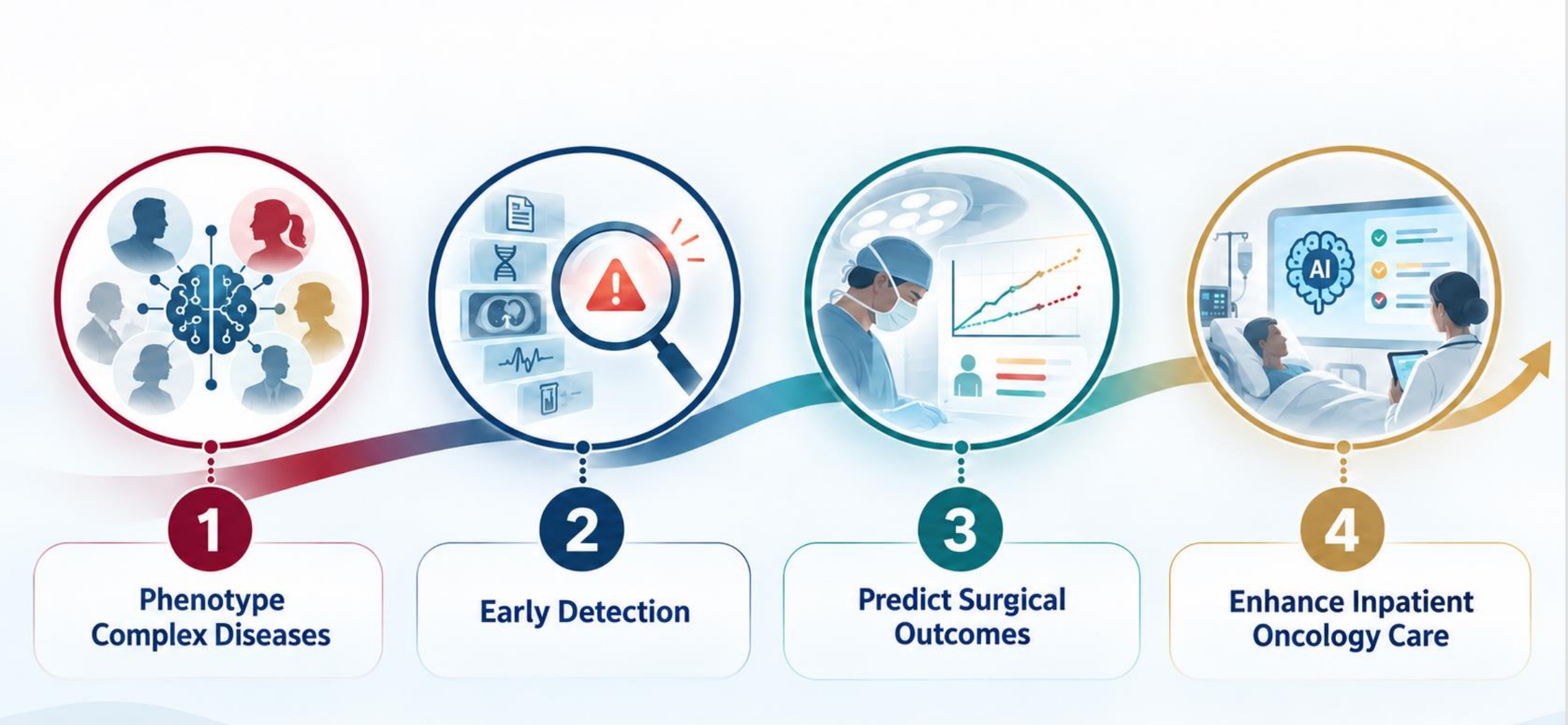


Foundation Model
145M parameters; pretrained on 2.57M Stanford patients; enriched with 5K CSM-associated codes.

Clinically Guided
391K-parameter, 3-layer neural network using counts of 497 clinician-selected codes.

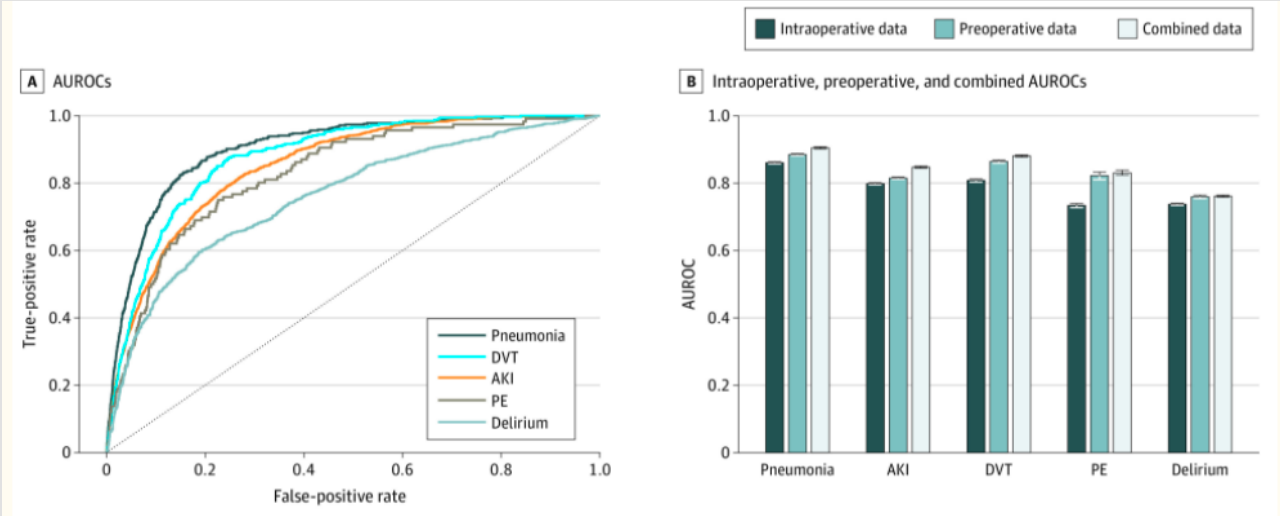
Yakdan S, Warner BC, et al. Clinically-guided models or foundation models? Predicting cervical spondylotic myelopathy from electronic health records. *npj Digital Medicine*. 2026;9:153.

AI Across the Care Continuum



Predict Postoperative Complications

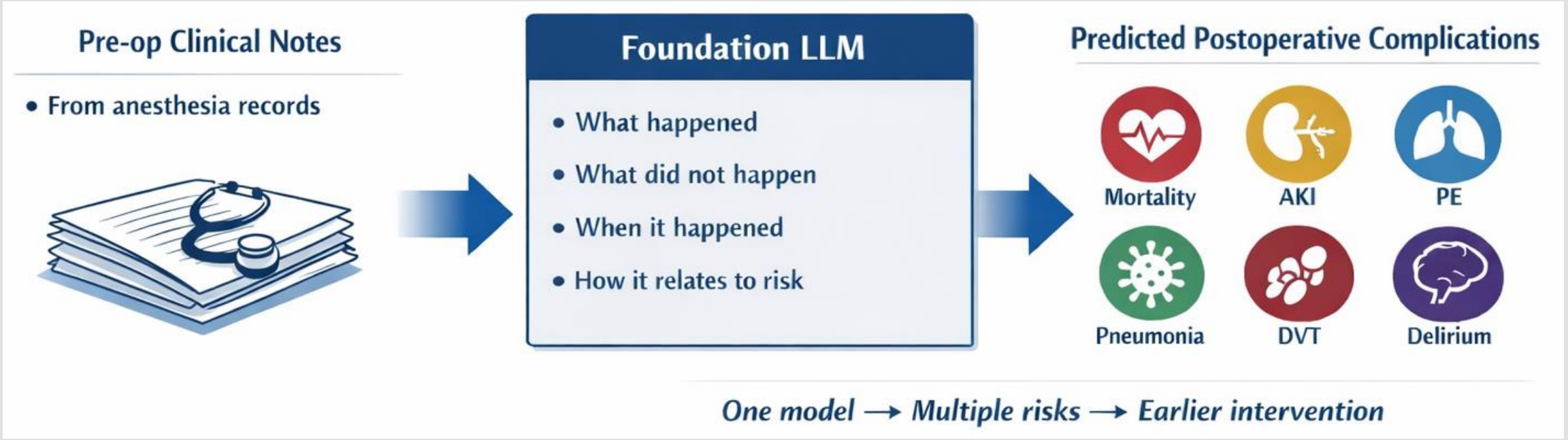
- Benefits of **predictive** models
  - Preemptive and early identification of risk factors
  - Anticipatory management for perioperative contingency planning
  - Shortened hospital stays and reduced complication risks
- Predictive models use **structured** EHR data



B. Xue, D. Li, C. Lu, C.R. King, T. Wildes, M.S. Avidan, T. Kannampallil, and J. Abraham, Use of Machine Learning to Develop and Evaluate Models Using Preoperative and Intraoperative Data to Identify Risks of Postoperative Complications, *JAMA Network Open*, 4(3):e212240, 2021.

Predict Postoperative Risks from Clinical Notes

- Clinical notes capture nuanced clinical judgment that structured data cannot.
- **Large Language Models (LLMs)** translate narrative documentation into risk signals.

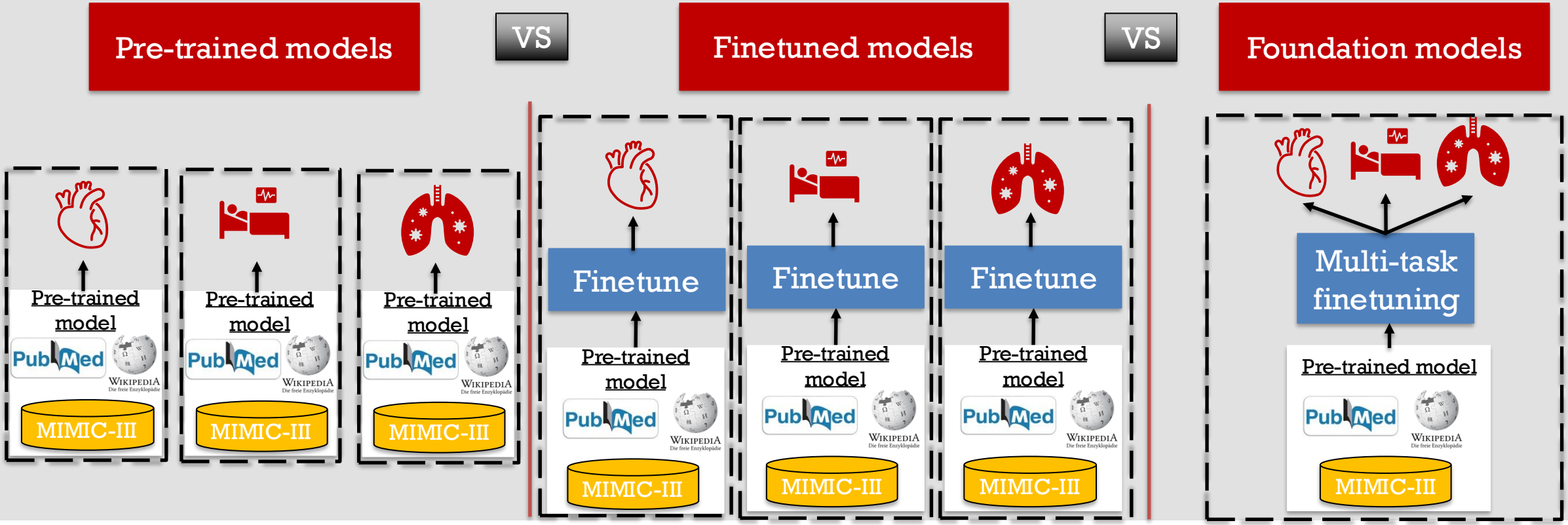


Dataset: 84,875 pre-operative anesthesia notes from Barnes-Jewish Hospital (BJH)

Work with Joanna Abraham, Thomas Kannampallil (Anesthesiology), Charles Alba (DCDS)

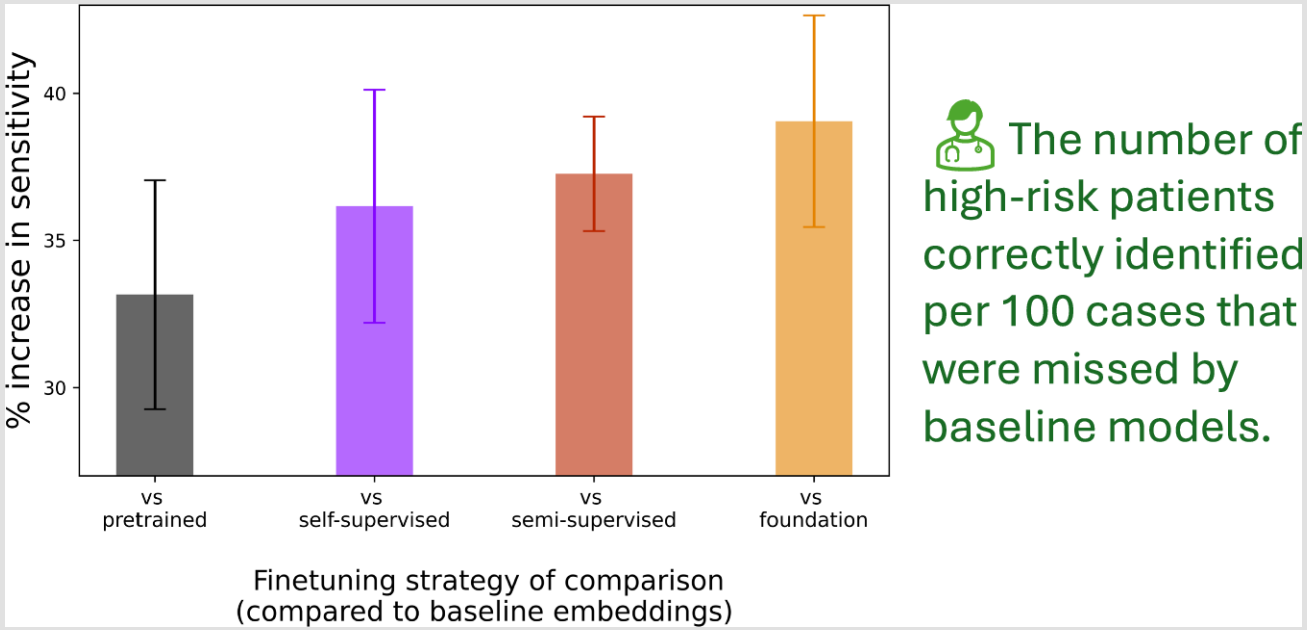
LLMs for Predicting Postoperative Risks

1. Do **pre-trained** LLMs outperform traditional NLP?
2. Does **fine-tuning** to surgical notes improve performance?
3. Can a single **foundation** model predict multiple risks?



Language Models Improve Surgical Risk Prediction

- Pretrained: **+33** percentage point increase over NLP in sensitivity (at 95% specificity)
- **One** foundation model predicts **multiple** complications
  - **Outperforms** individually fine-tuned models
  - **Simplifies** clinical deployment



The number of high-risk patients correctly identified per 100 cases that were missed by baseline models.

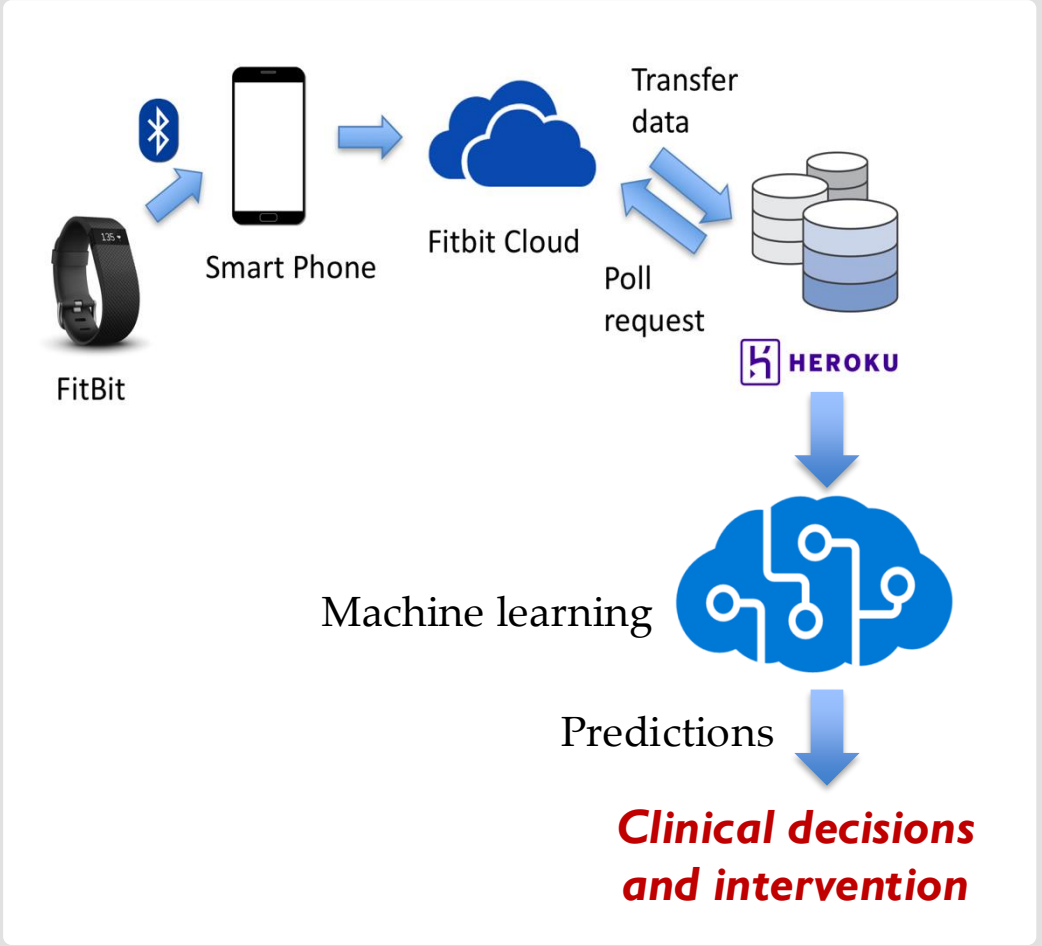
SurgicalPLAN

ACS AI Course

Alba C, Xue B, Abraham J, Kannampallil T, Lu C. The foundational capabilities of large language models in predicting postoperative risks using clinical notes. *npj Digital Medicine*. 8, 95 (2025).

Decision Support for Pancreatic Surgery

- Pancreatic cancer has a 5-year survival rate less than 5%.
- Surgery is commonly followed by complications.
  - Pancreatectomy: 90-day mortality rate over 4% and serious morbidity rates over 20%.
- Predict postoperative complications before surgery
  - **Decision support**: suitability for surgery
  - **Intervention**: prehabilitation



Work with Chet Hammill (Surgery), Jingwen Zhang (CSE)

Robust Feature Engineering Pipeline



Daily Feature Extraction



Step Count

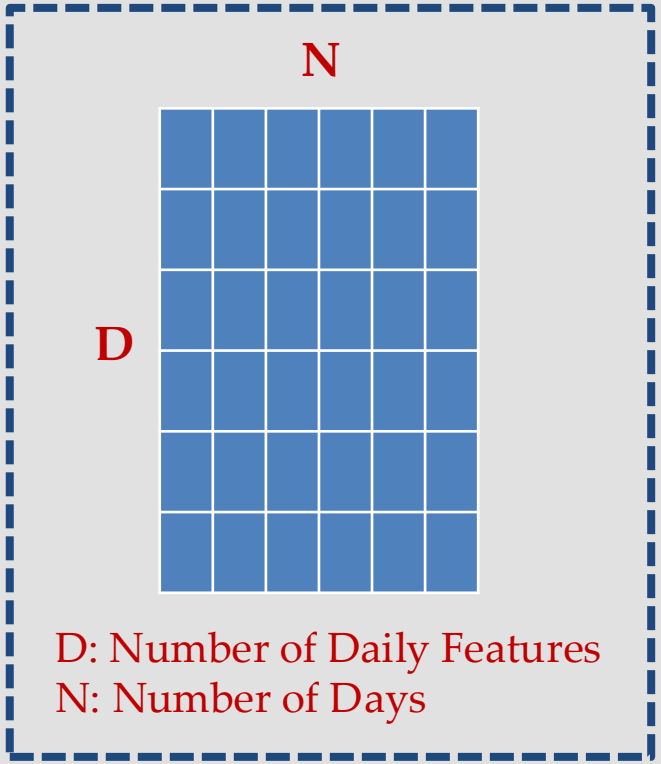


Heart Rate

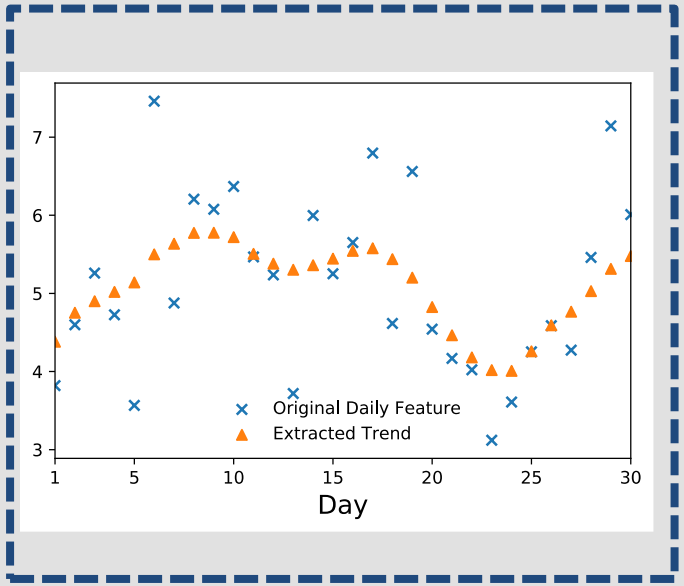


Sleep Stage

Wearable Time Series



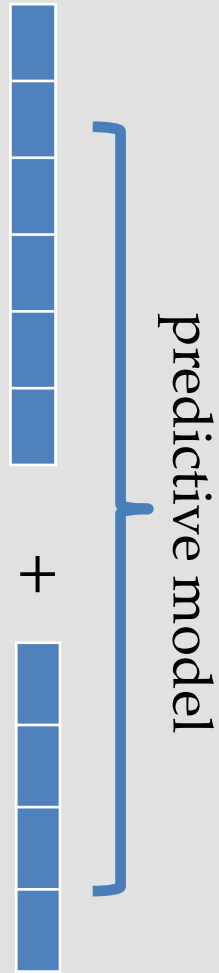
High-level Feature Extraction







Clinical Characteristics



Predict Complications after Pancreatic Surgery

Machine learning outperforms standard surgical risk scores.

- x2 AUPRC
- **x3 sensitivity at the same specificity**

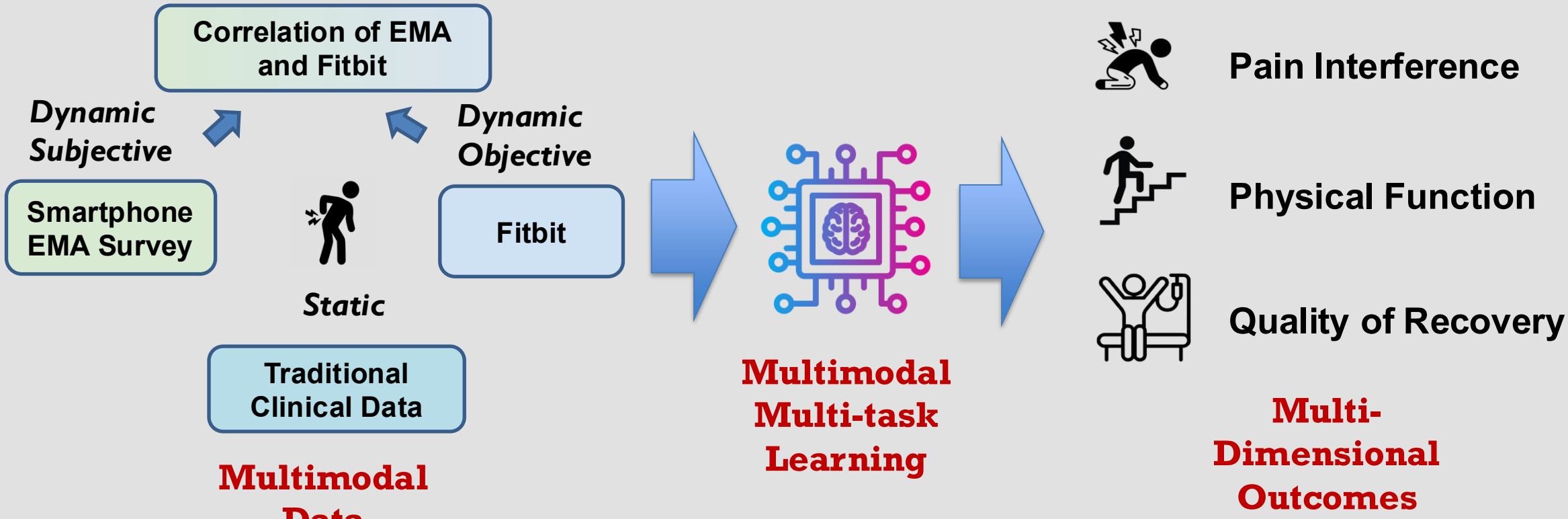
Data Source	AUROC	AUPRC	Sensitivity	Specificity
Random weighted classifier	0.5097 (0.0585)	0.4322 (0.0469)	0.1520 (0.0854)	0.8583 (0.0504)
NSQIP with Clinical Characteristics	0.6114 (0.0000)	0.4075 (0.0000)	0.2800 (0.0000)	0.8571 (0.0000)
ML with Clinical Characteristics	0.7632 (0.0085)	0.7374 (0.0206)	0.5800 (0.0699)	0.8583 (0.0083)
Wearable Data	0.7326 (0.0074)	0.7192 (0.0154)	0.5480 (0.0440)	0.8583 (0.0083)
Clinical Characteristics + Wearable Data	**0.8802 (0.0050)**	**0.8871 (0.0087)**	**0.8320 (0.0160)**	0.8583 (0.0083)

NSQIP: American College of Surgeons National Surgical Quality Improvement Program

Expanding to the Surgical Prehabilitation and Readiness (SPAR) program

J. Zhang, D. Li, R. Dai, H. Cos, G.A. Williams, L. Raper, C.W. Hammill, and C. Lu, Predicting Post-Operative Complications with Wearables: A Case Study with Patients Undergoing Pancreatic Surgery, *Proceedings of the ACM on Interactive, Mobile, Wearable and Ubiquitous Technologies*, 6(2), Article 87, July 2022.

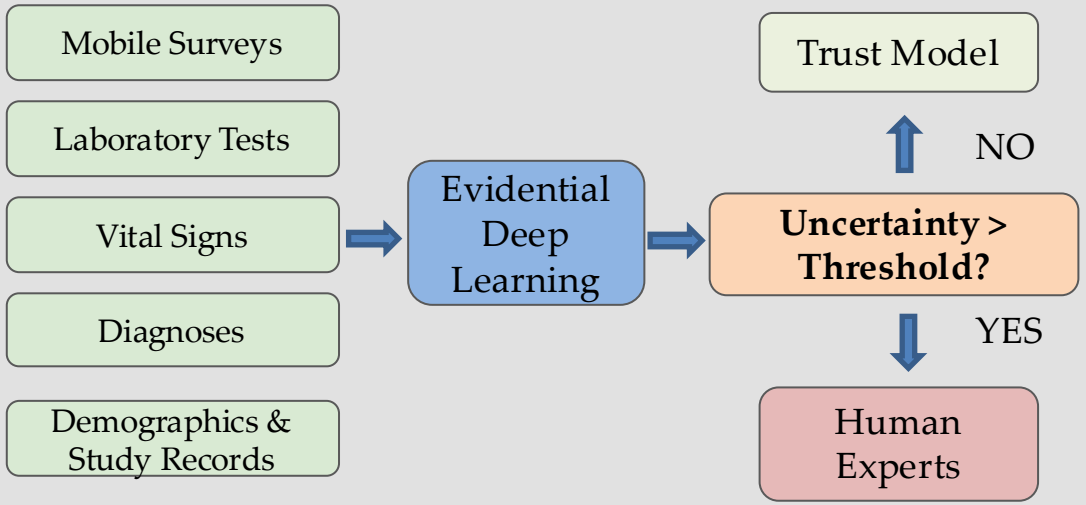
Predicting Lumbar Spine Surgical Outcomes

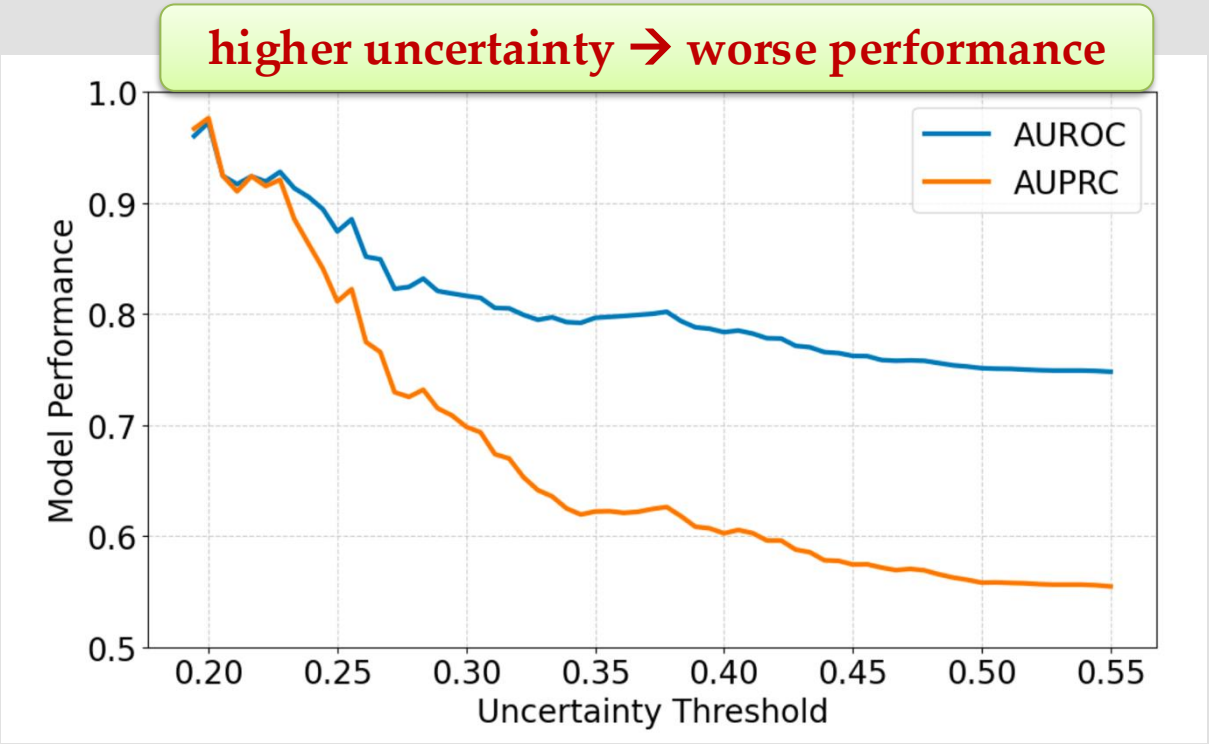


Xu Z, Zhang J, Greenberg J, Frumkin M, Javeed S, Zhang J, Benedict B, Botterbush K, Rodebaugh T, Ray W, Lu C. Predicting multi-dimensional surgical outcomes with multi-modal mobile sensing: A case study with patients undergoing lumbar spine surgery. *Proceedings of the ACM on Interactive, Mobile, Wearable and Ubiquitous Technologies.* 2024;8(2).

Predict Postsurgical Persistent Pain

- Pain persists 3+ months after surgery
- Multimodal data: pre-operative mobile sensing and clinical data
- **Uncertainty-aware**: support clinical decisions with estimated uncertainty

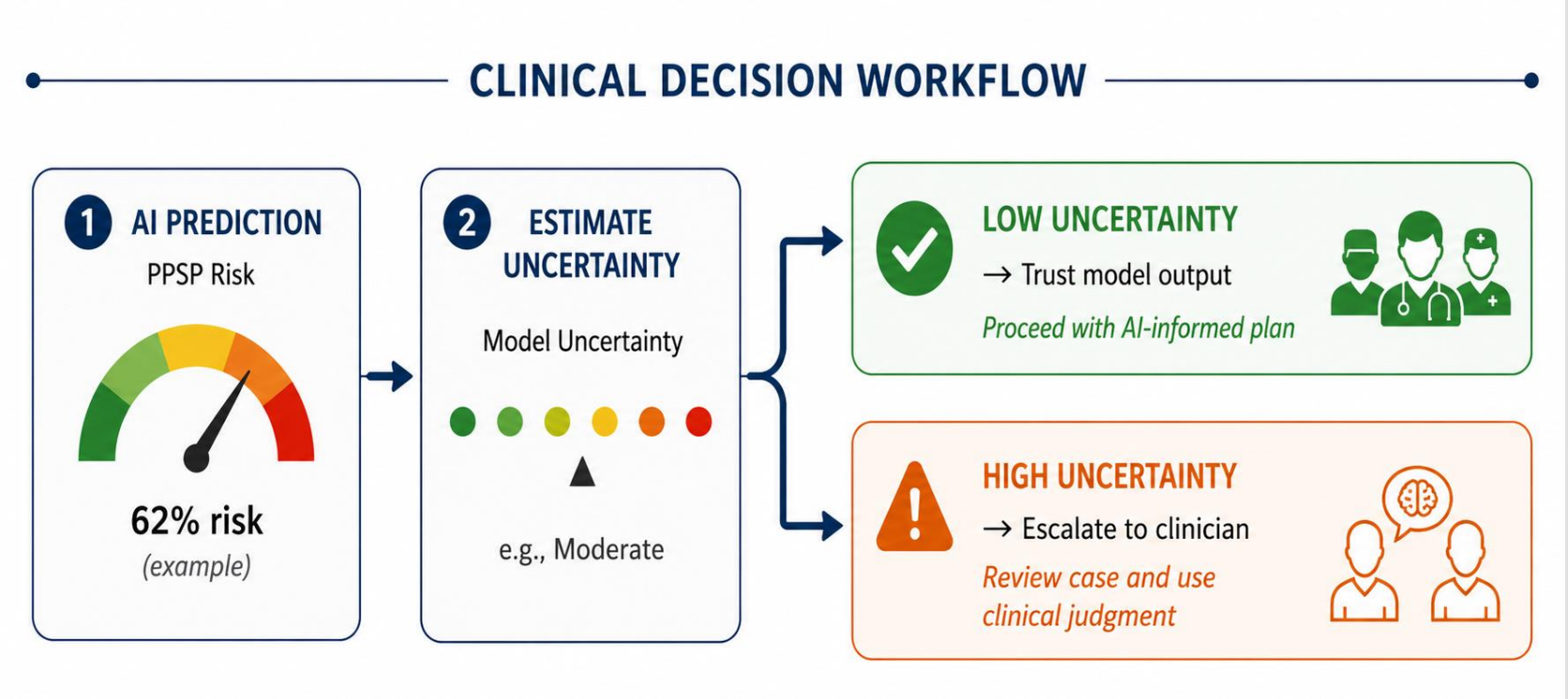




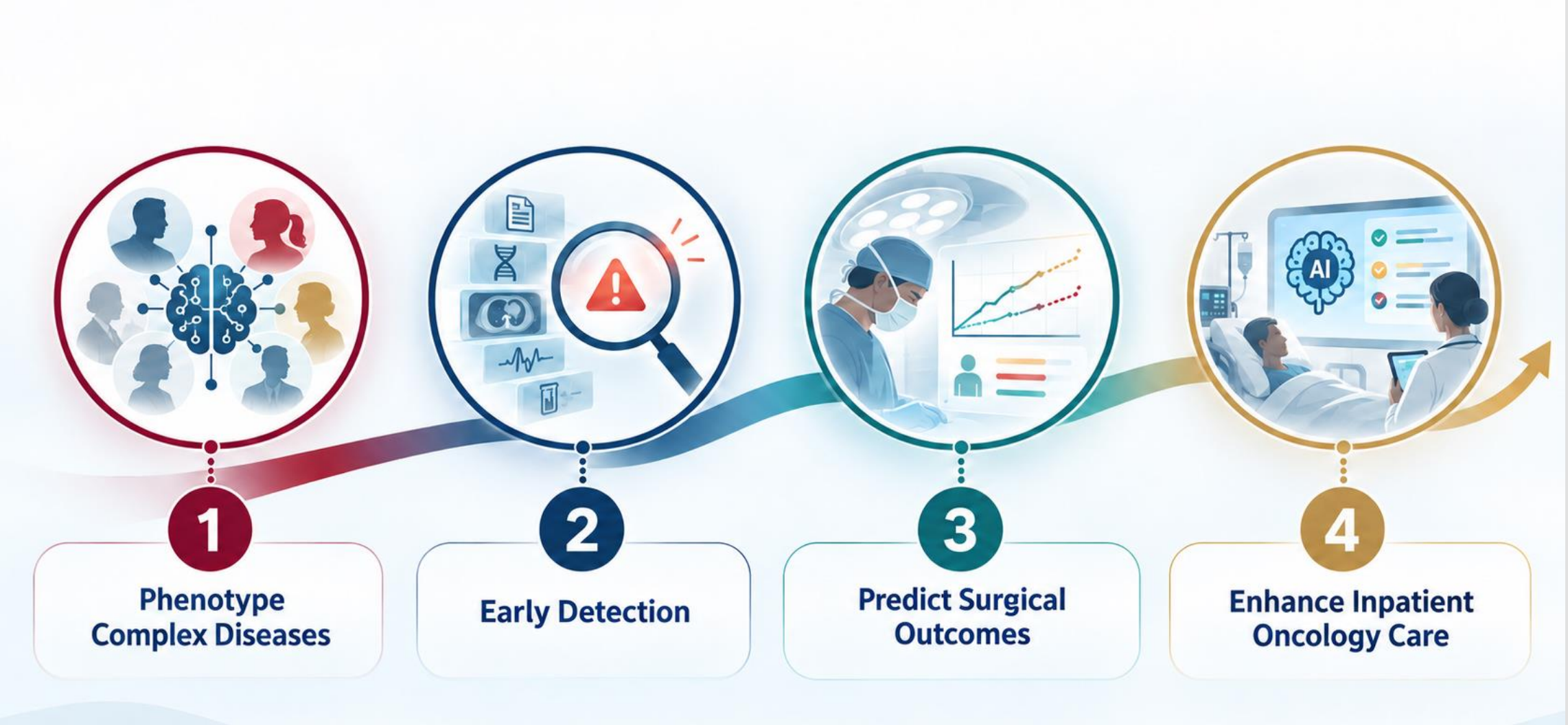
Xu Z, Zhang J, Haroutounian S, Liu H, Cao Z, Messner GR, Alaverdyan HB, Ahuja S, Koshy R, Hanns J, Frumkin M, Rodebaugh TL, Lu C. Incorporating uncertainty in predictive models using mobile sensing and clinical data: a case study on persistent post-surgical pain. *Proceedings of the ACM on Interactive, Mobile, Wearable and Ubiquitous Technologies*. 2025;9(2):58.

Why Uncertainty Matters in Surgery

- **High-stakes** decisions: complications, recovery, long-term outcomes
- AI can be **confidently wrong** → risk of misleading decisions
- **Uncertainty** determines when to trust AI and when to defer to clinicians



AI Across the Care Continuum



Oncology Early Warning System



- **6.4%** of oncology inpatients have ICU transfer; **2.7%** of them die on the hospital wards
- Predict clinical deterioration based on heterogeneous EHR data
- **CrossNet**: Unified deep recurrent model for integrating static and time-series inputs

CrossNet predicts **10x** deterioration events than MEWS at the same false alarm rate.

MEWS: Modified Early Warning Scores

Model	Alarm rate control		False alarm control
	Sensitivity	Specificity	Sensitivity
MEWS	0.3358(0.0115)	0.8257(0.0142)	0.0392(0.0062)
C. BRITS	0.3899(0.0134)	0.9394(0.0097)	0.3581(0.0092)
S. BRITS	0.3891(0.0122)	0.9396(0.0105)	0.3586(0.0131)
CrossNet	**0.4218(0.0130)**	**0.9486(0.0093)**	**0.3952(0.0118)**

Li D, Lyons P, Klaus J, Gage B, Kollef M, Lu C. Integrating static and time-series data in deep recurrent models for oncology early warning systems. *Proceedings of the ACM International Conference on Information and Knowledge Management (CIKM)*. 2021.

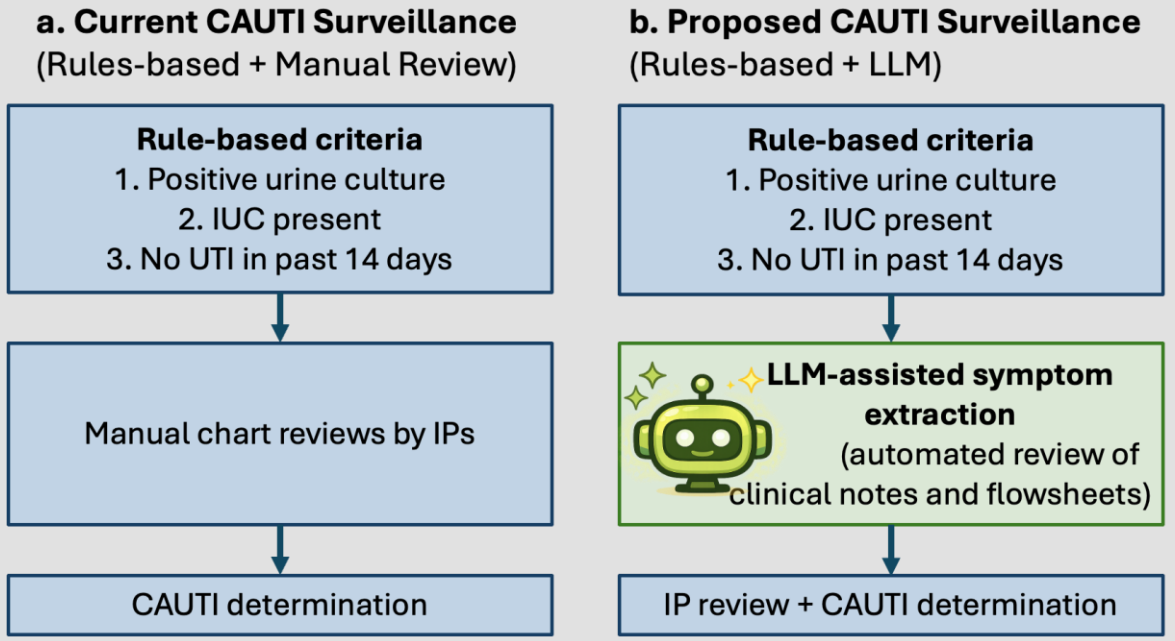
CAUTI Surveillance Requires Manual Chart Review

CAUTIs represent **75%** of healthcare associated UTIs

- Acute care hospitals report CAUTIs through CDC National Healthcare Safety Network (NHSN).
- CAUTI surveillance requires time-consuming, error-prone **manual chart review**.
- Rule-based algorithms miss subjective symptoms documented in clinical notes.

Goal

Automate symptom extraction with LLM
while faithfully implementing NHSN criteria



Work with Abby Sung, Joshua Nordman, Jonas Marschall, Andrew Atkinson (Infectious Diseases), Claire Najjuuko (DCDS)

LLM Improves CAUTI Surveillance

Data

- 919 potential CAUTI cases at Barnes-Jewish Hospital (Jan 2021–Jun 2024)
- Adjudicated by trained infection preventionists
  - 291 confirmed CAUTIs (31.7%)
  - 628 non-CAUTIs (68.3%)

Results

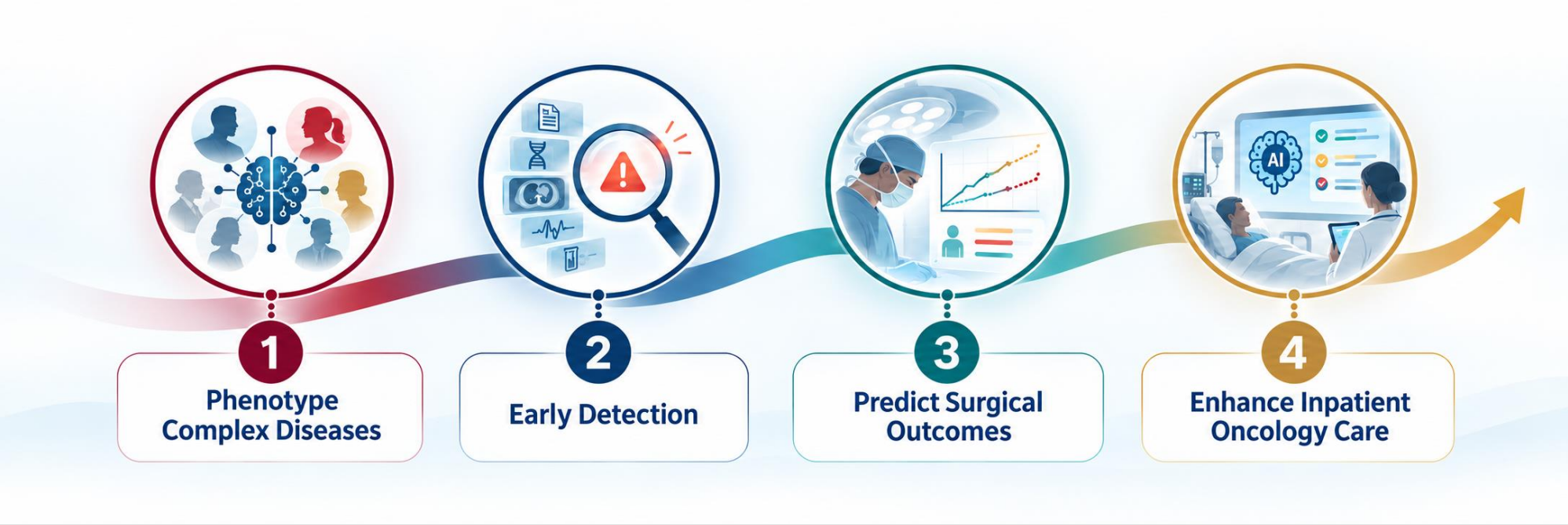
Method	Sensitivity	Specificity
Rules alone	77.7%	97.1%
Rules + Traditional NLP	80.4%	95.2%
Rules + LLM-CLEAR	**93.3%**	**98.5%**
LLM alone	88.7%	86.3%

CLEAR: Clinical Entity Augmented Retrieval

- LLM-enhanced NHSN rules achieved the highest sensitivity and specificity.

Nordman J, Najjuuko C, et al. The Best of Both Worlds: How Combining a Large Language Model and a Rule-Based Algorithm Makes Catheter-Associated Urinary Tract Infection Surveillance More Efficient, Clinical Infectious Diseases. 2026;83(1):e120–e126.

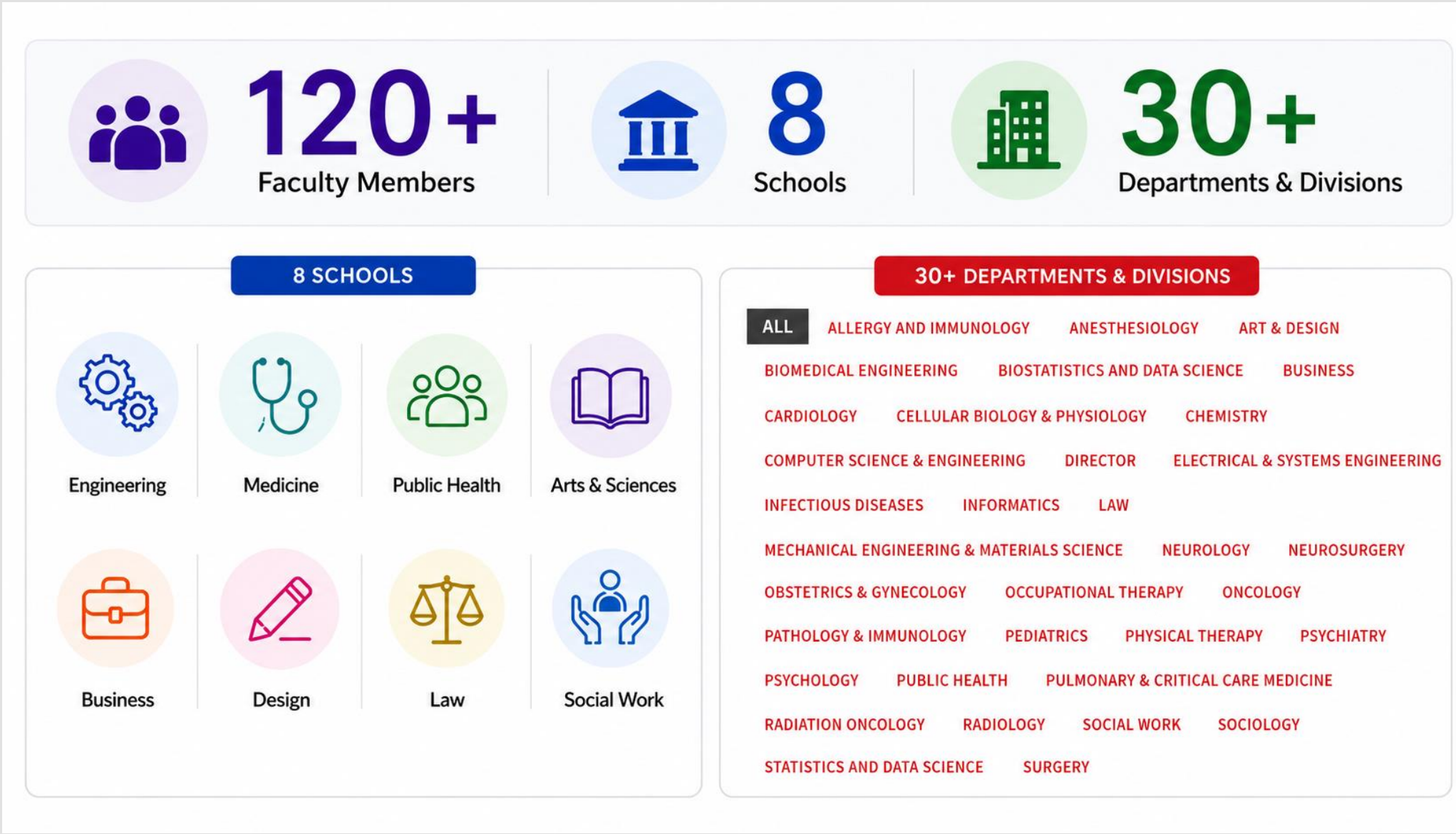
AI transforms oncology across the care continuum



— **Reveal** cancer phenotypes
— **Detect** earlier, intervene sooner
— **Predict** treatment and outcomes
— **Deliver** smarter, more efficient care

Beyond today: Accelerate discovery with multimodal AI

AI for Health Institute



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AIHealth Venture Day

1-6:30 p.m. | Sept. 23, 2026 | Umrath Hall

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- Insights from investors & founders
- Entrepreneurship & collaboration

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Where Health AI Meets Investment & Entrepreneurship

AI for Health Symposium

Power, Promise and Public Good

THURSDAY, OCTOBER 29

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aihealth.wustl.edu/symposium

The future of oncology is AI-enabled. Let's build it together!

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aihealth.wustl.edu