

Patient Trajectories with AI: from Generation to Insight

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<https://mai-research.github.io/>



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Dr Hugh Logan-Ellis

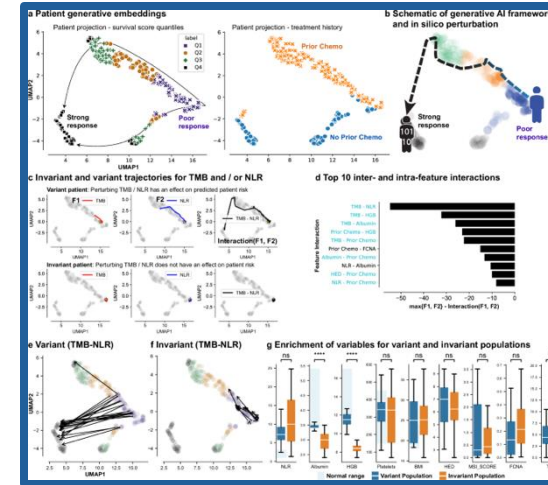


Mr Joseph Arul Raj

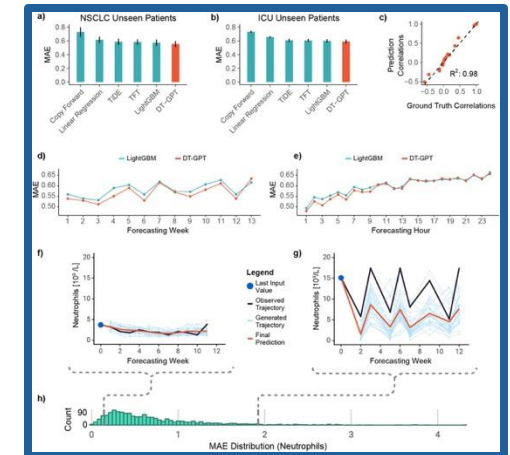
AI In Medicine: Patient Trajectory Prediction

- Trust
- Bias
- Fairness
- Skewed predictions
- Robustness
- Data requirements
- Etc..
- Etc..
- Etc...

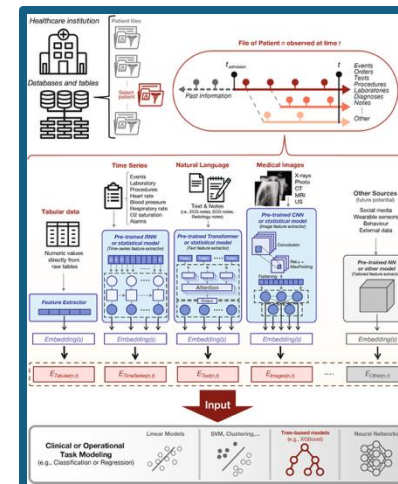
IEEE



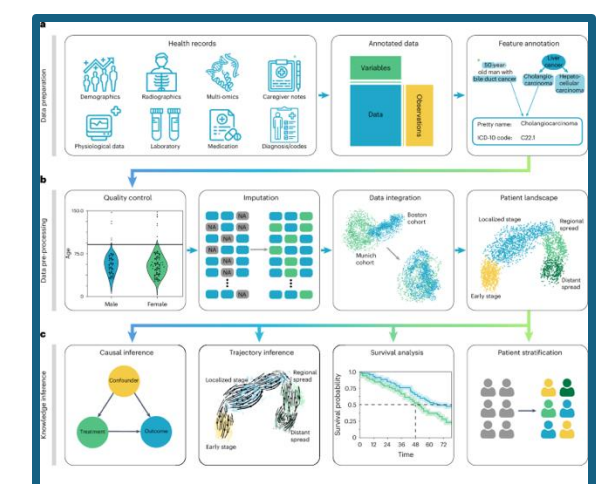
JAMIA



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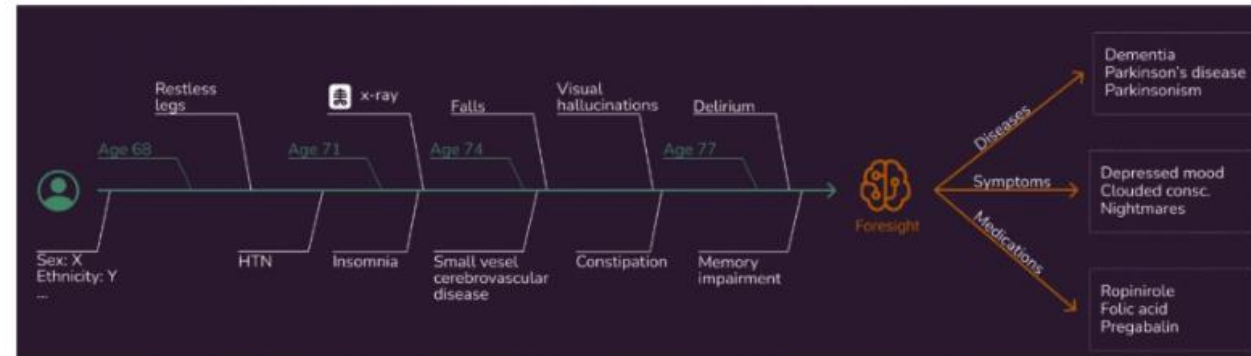
Nature



Foresight—a generative pretrained transformer for modelling of patient timelines using electronic health records: a retrospective modelling study

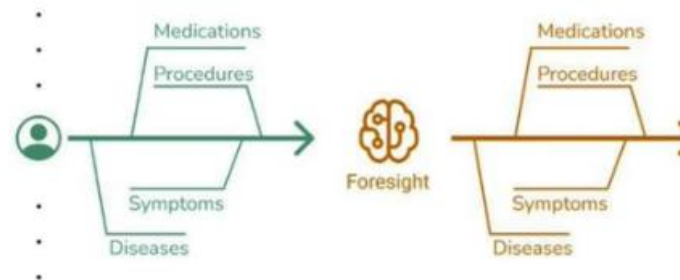
[Zeljko Kraljevic, MSc^{a,e}](#) · [Dan Bean, PhD^{a,e}](#) · [Anthony Shek, PhD^{b,c}](#) · [Rebecca Bendayan, PhD^{a,e}](#) · [Prof Harry Hemingway, PhD^{d,f}](#) · [Joshua Au Yeung, MBBS^{b,c}](#) · et al. [Show more](#)

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Patient Timelines - Historical data

Patient Timelines - Forecasted



Foresight: GPT-based Forecasting Pipeline

Foresight

ctomlinson.net/project/2023-foresight-sde/

Dr Chris Tomlinson

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Foresight: a generative AI model of patient trajectories across the COVID-19 pandemic

Last updated on May 8, 2025

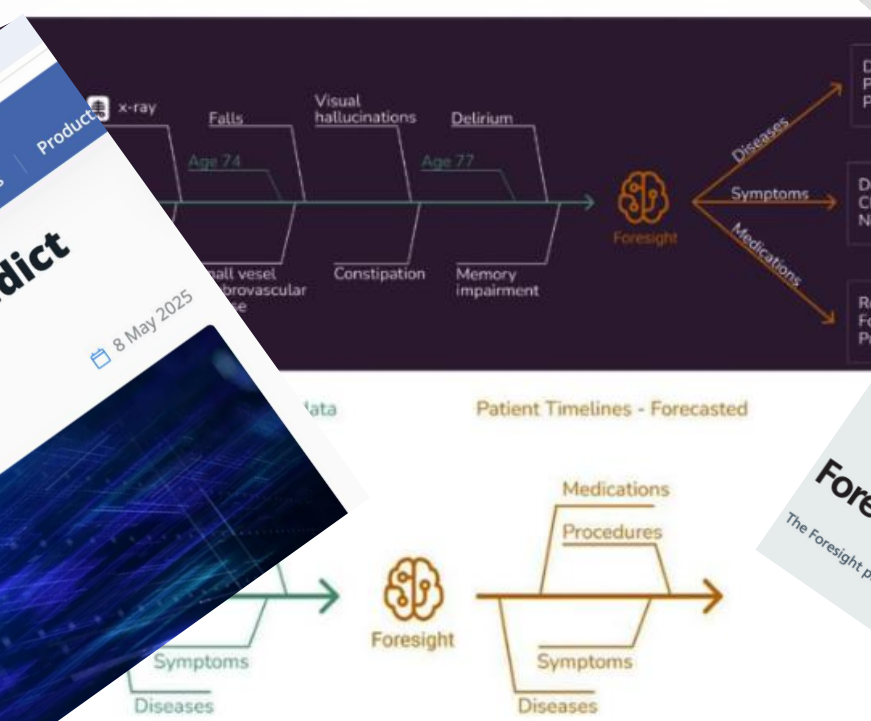
digitalhealth.net/2025/05/researchers-pilot-ai-model-to-predict-future-health-outcomes/

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Researchers pilot AI model to predict future health outcomes

AI AND DATA, NEWS

8 May 2025



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MAY 7, 2025

Foresight AI – Groundbreaking AI trained on de-identified patient data predicts healthcare needs

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digital.nhs.uk/data-and-information/research-powered-by-data/case-studies/foresight-ai

NHS England Digital

NHS Digital > Data and information > Research powered by data > Case studies > Foresight AI

Foresight AI case study

The Foresight project represents a groundbreaking AI initiative to transform predictive healthcare in the UK.

Services Data Cyber Developer News About

Foresight: GPT-based Forecasting Pipeline

Extreme Case: In-hospital Cardiac Arrest (IHCA) Prediction from General Wards

Aim: Evaluate Foresight's ability to serve as a tool for early recognition of IHCA from general wards data.

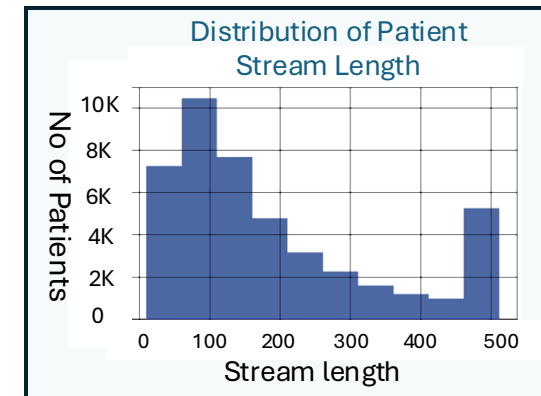
- IHCA is **complex** & multifaceted
- General ward patients are diverse
 - **Long-term** and **short-term** symptoms, diagnoses, procedures etc...
- General wards are **sparsely monitored**
 - Vital signs and lab tests (**numerical**) & observations (**text**)

Extreme Case: In-hospital Cardiac Arrest (IHCA) Prediction from General Wards

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- 1. **Statistical bias:** Foresight is good with patients with long trails of documents.

Most patients have less documents (younger patients, patients with less comorbidities, etc)

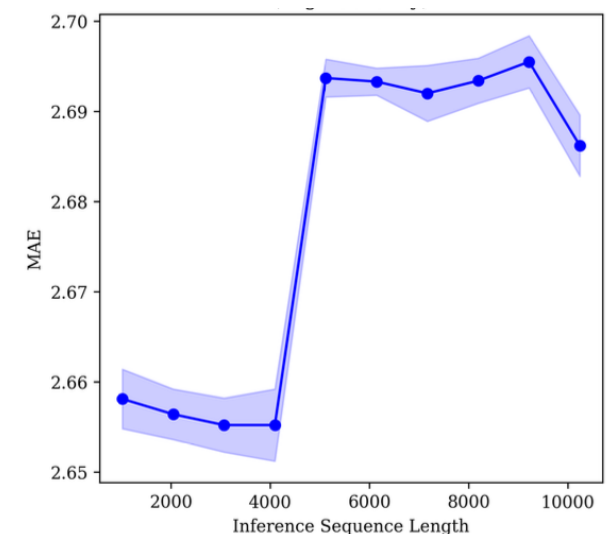
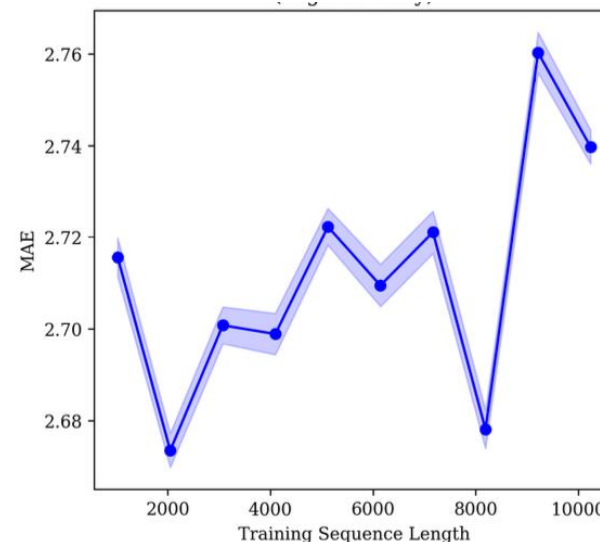
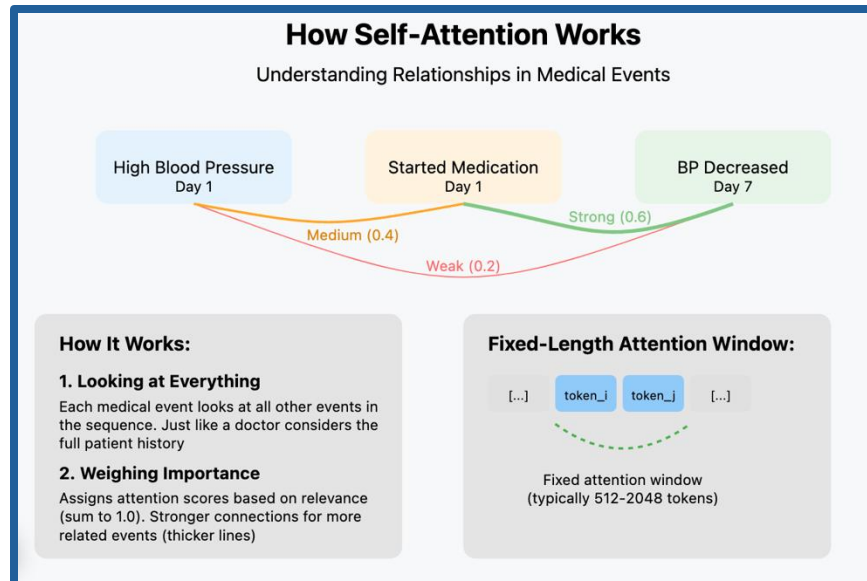
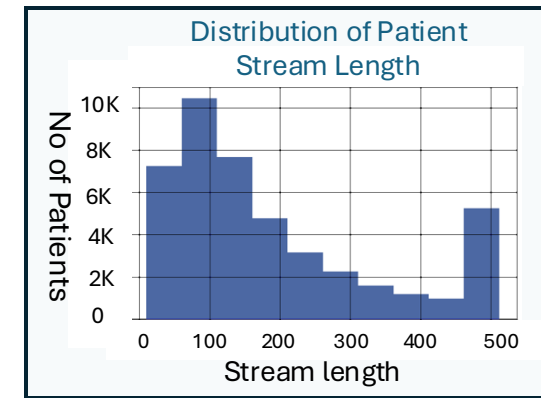


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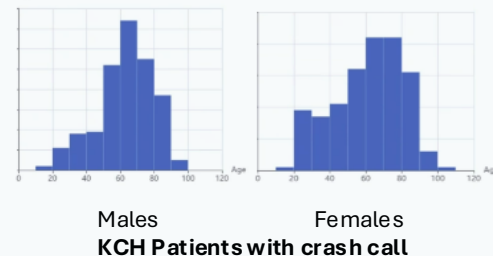
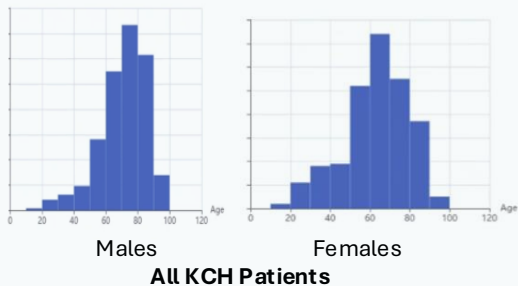
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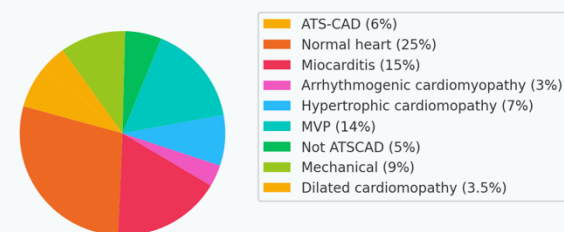
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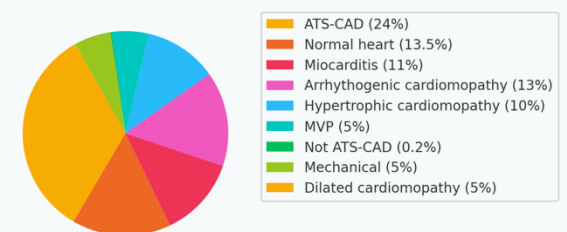
1. **Statistical bias:** Foresight is good with patients with long trails of documents.
2. **Structural bias:** Foresight's forecasts carry along the clinical and documentation bias within its training data



Female Gender



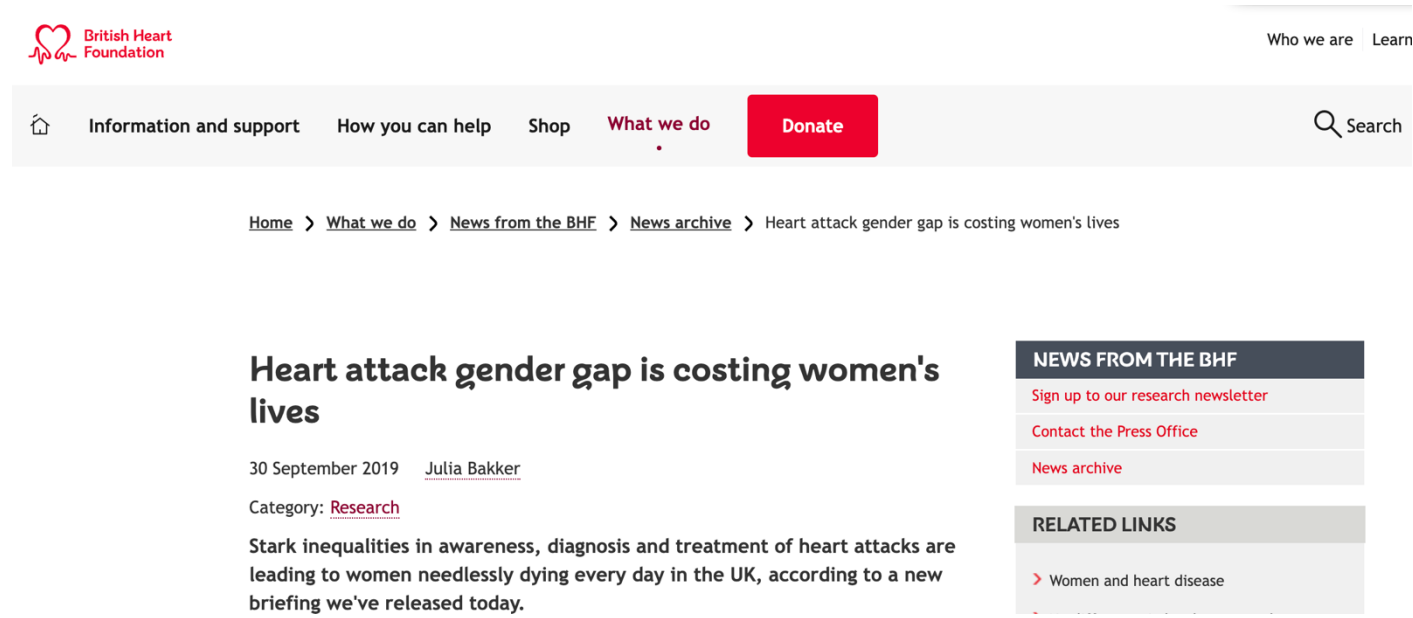
Male Gender



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The screenshot shows the British Heart Foundation (BHF) website. The header includes the BHF logo and navigation links: "Who we are" and "Learn". Below the header is a navigation bar with links: "Information and support", "How you can help", "Shop", "What we do", and a red "Donate" button. A search icon and "Search" text are on the right. The main content area shows a breadcrumb trail: "Home > What we do > News from the BHF > News archive > Heart attack gender gap is costing women's lives". The article title is "Heart attack gender gap is costing women's lives", dated "30 September 2019" by "Julia Bakker". The category is "Research". The article text begins: "Stark inequalities in awareness, diagnosis and treatment of heart attacks are leading to women needlessly dying every day in the UK, according to a new briefing we've released today." On the right, there is a sidebar with "NEWS FROM THE BHF" links: "Sign up to our research newsletter", "Contact the Press Office", and "News archive". Below that is a "RELATED LINKS" section with a link: "> Women and heart disease".

British Heart Foundation

Who we are Learn

Information and support How you can help Shop What we do Donate

Search

Home > What we do > News from the BHF > News archive > Heart attack gender gap is costing women's lives

Heart attack gender gap is costing women's lives

30 September 2019 Julia Bakker

Category: Research

Stark inequalities in awareness, diagnosis and treatment of heart attacks are leading to women needlessly dying every day in the UK, according to a new briefing we've released today.

NEWS FROM THE BHF

- Sign up to our research newsletter
- Contact the Press Office
- News archive

RELATED LINKS

- > Women and heart disease

What we did not do ...

- **Train on more data..**

- The status quo
- It will not help with structural bias



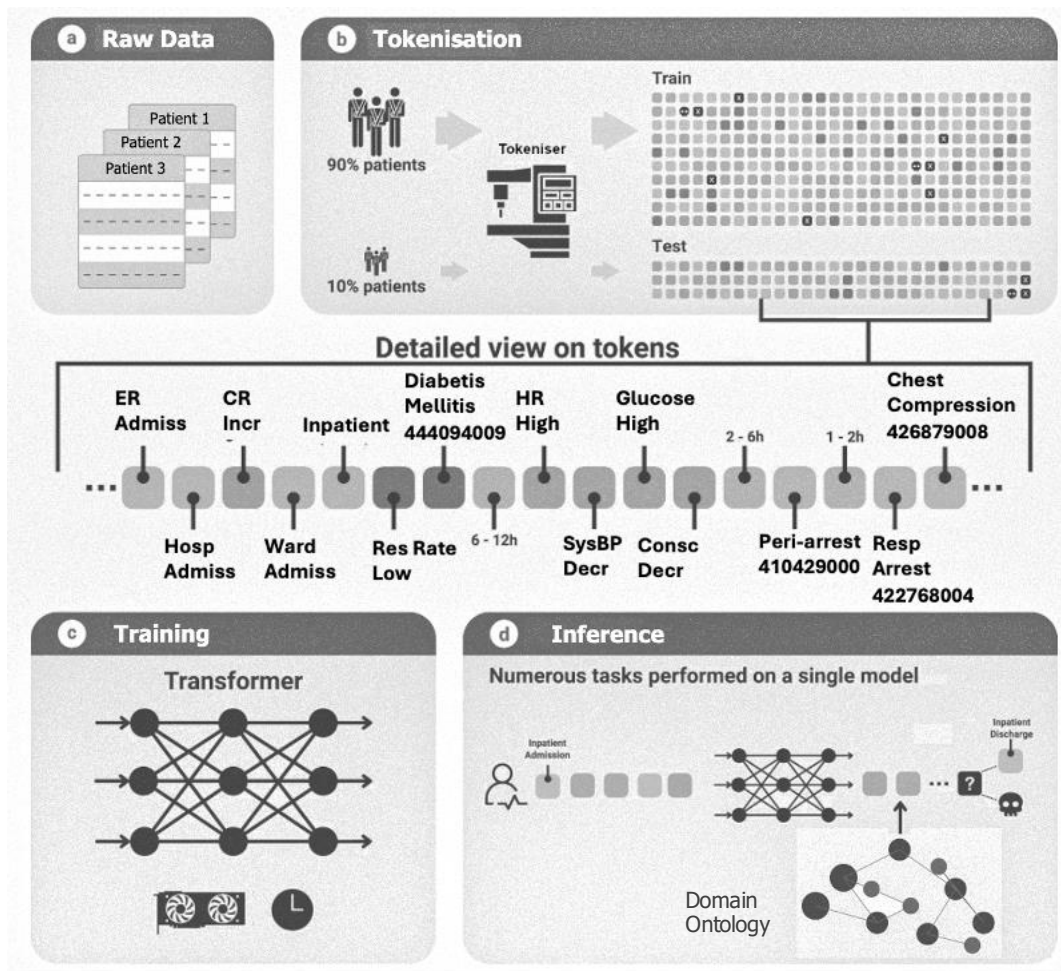
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Our Solution – METHOD: Modular Efficient Transformer for Healthcare Outcome Discovery

EHR-oriented
representation of
medical events

Modified EHR-aligned
architecture

Addresses statistical bias



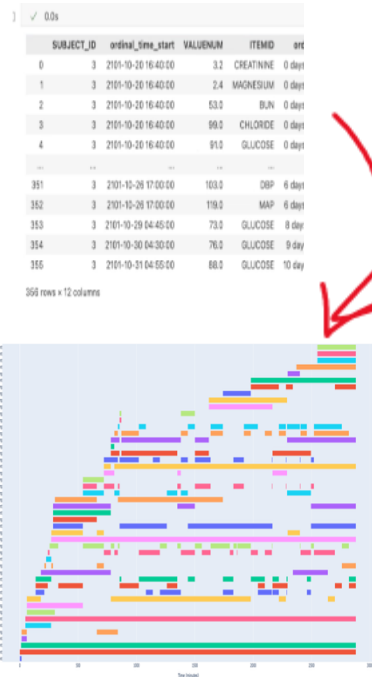
PHASE I

PHASE II

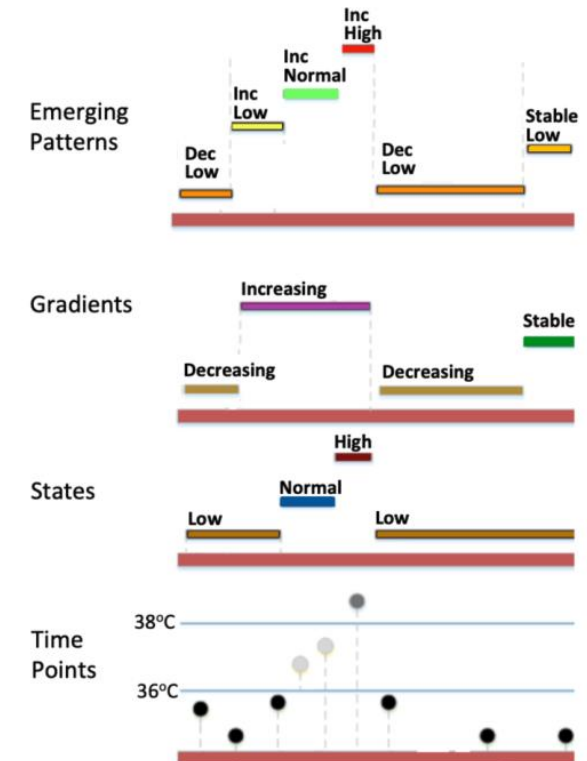
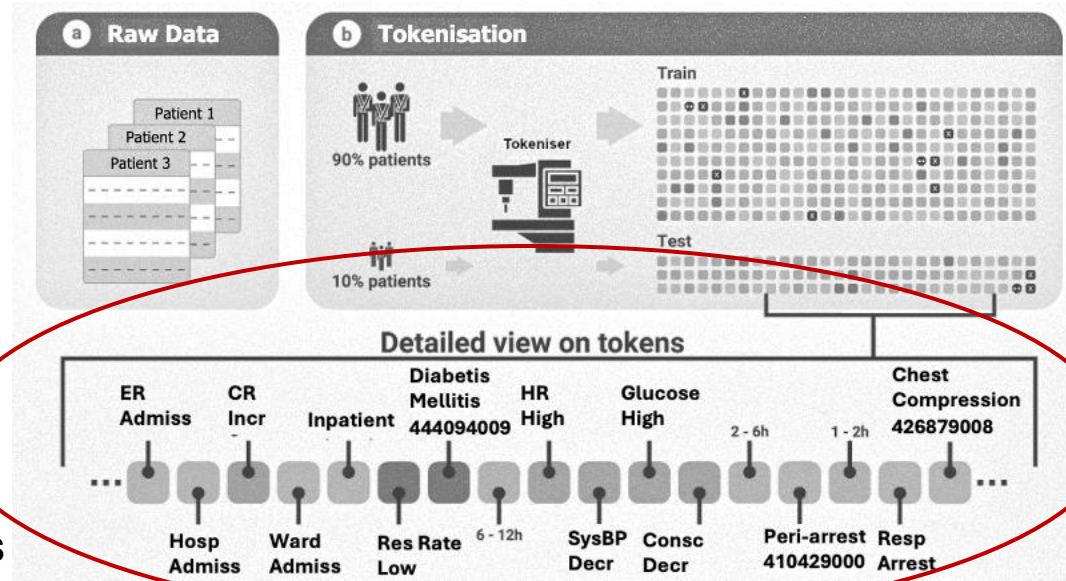
Alignment with medical
knowledge/guidelines

Addresses structural bias

Our Solution – METHOD: Modular Efficient Transformer for Healthcare Outcome Discovery



EHR-oriented
representation of
medical events



1826

ECAI 2020

G.D. Giacomo et al. (Eds.)

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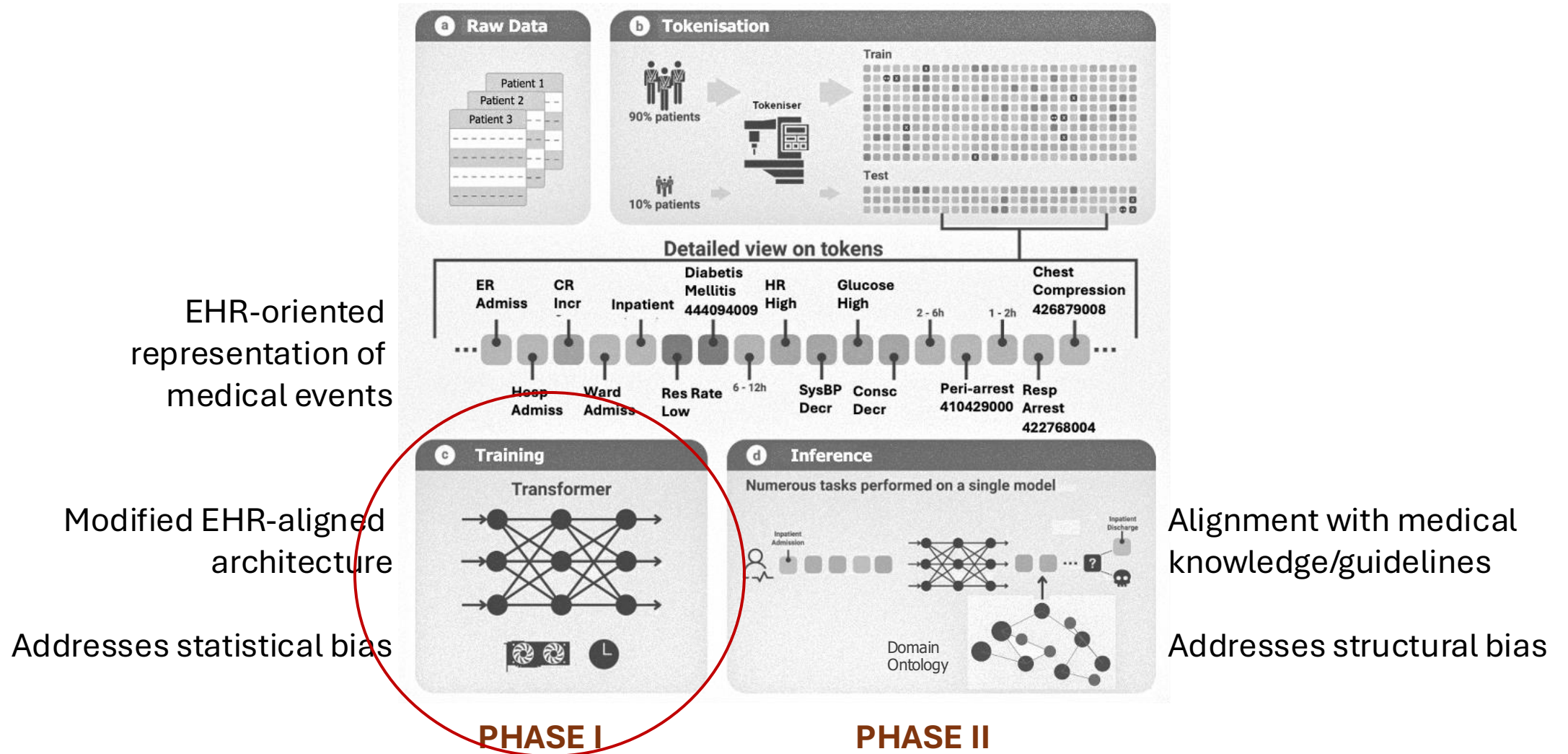
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doi:10.3233/FAIA200298

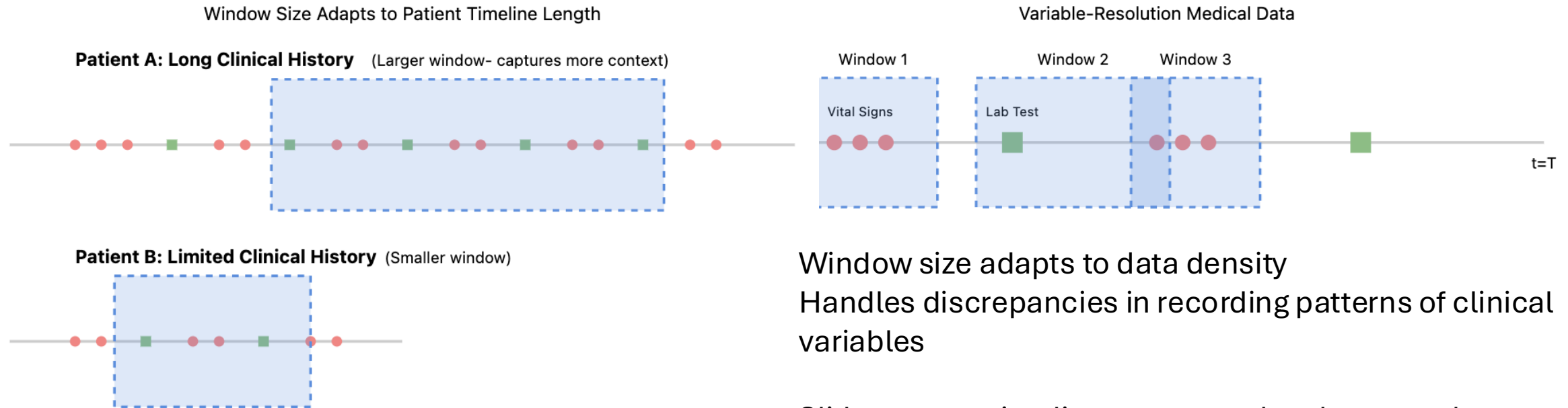
Modeling Rare Interactions in Time Series Data Through Qualitative Change: Application to Outcome Prediction in Intensive Care Units

Zina Ibrahim¹ and Honghan Wu² and Richard Dobson³

Our Solution – METHOD: Modular Efficient Transformer for Healthcare Outcome Discovery



Phase I: METHOD Architecture- Adaptive Sliding Window Attention



Window size grows with available patient history
Balances local & global dependencies

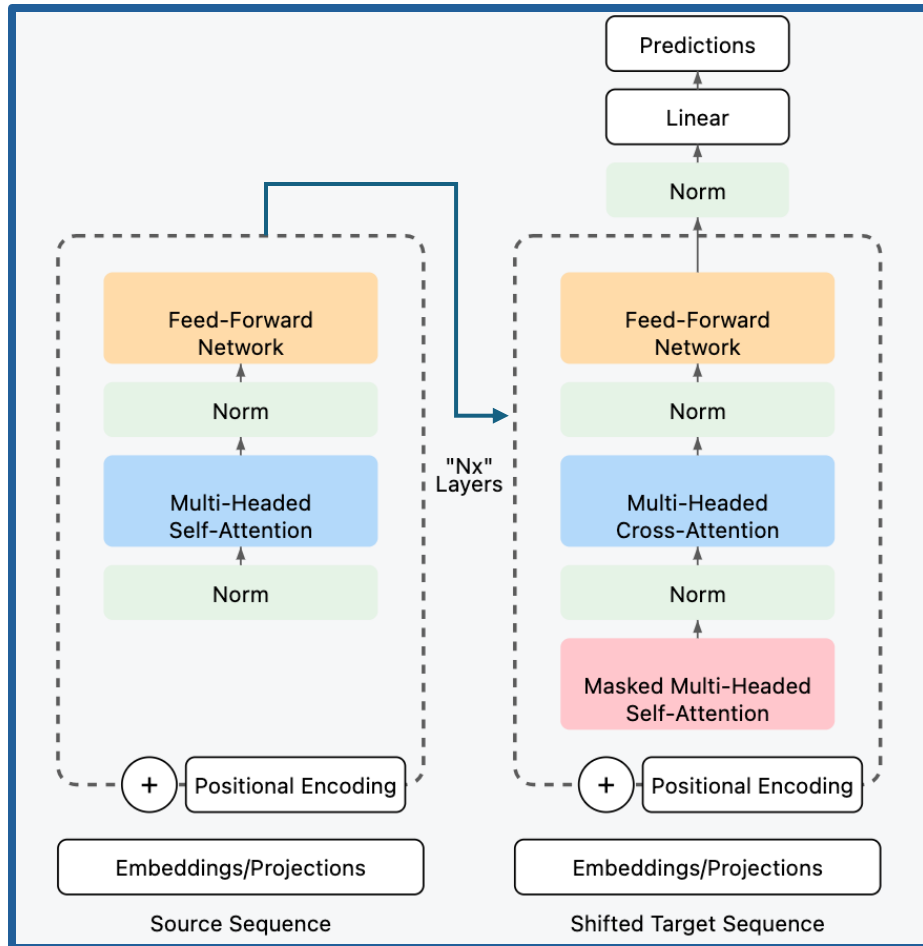
Window size adapts to data density
Handles discrepancies in recording patterns of clinical variables

Slides across timeline to capture local temporal relationships

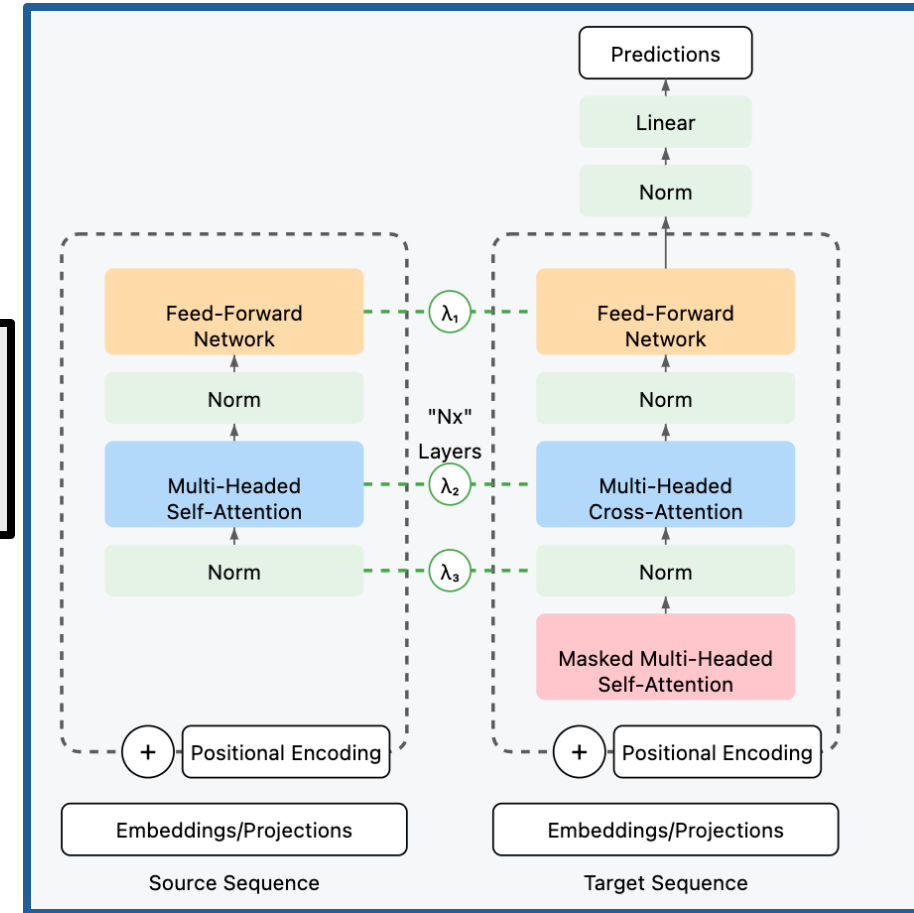


Dr. Linglong Qian

Phase I: Method's Architecture - U-Net Inspired Skip Attention



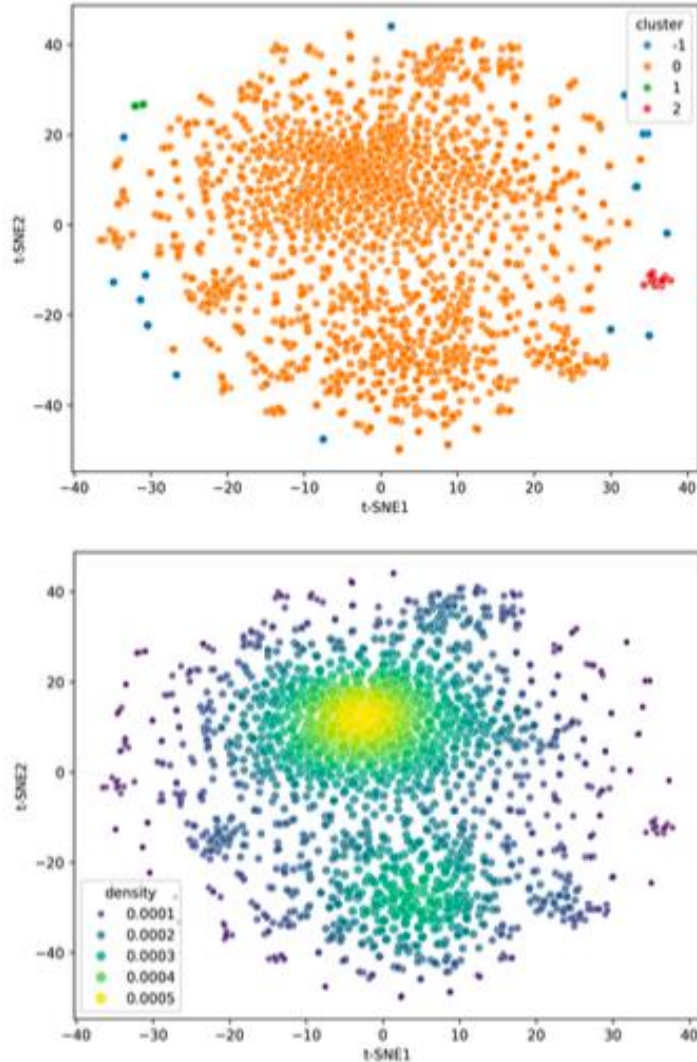
Traditional transformer handles information in a sequential fashion



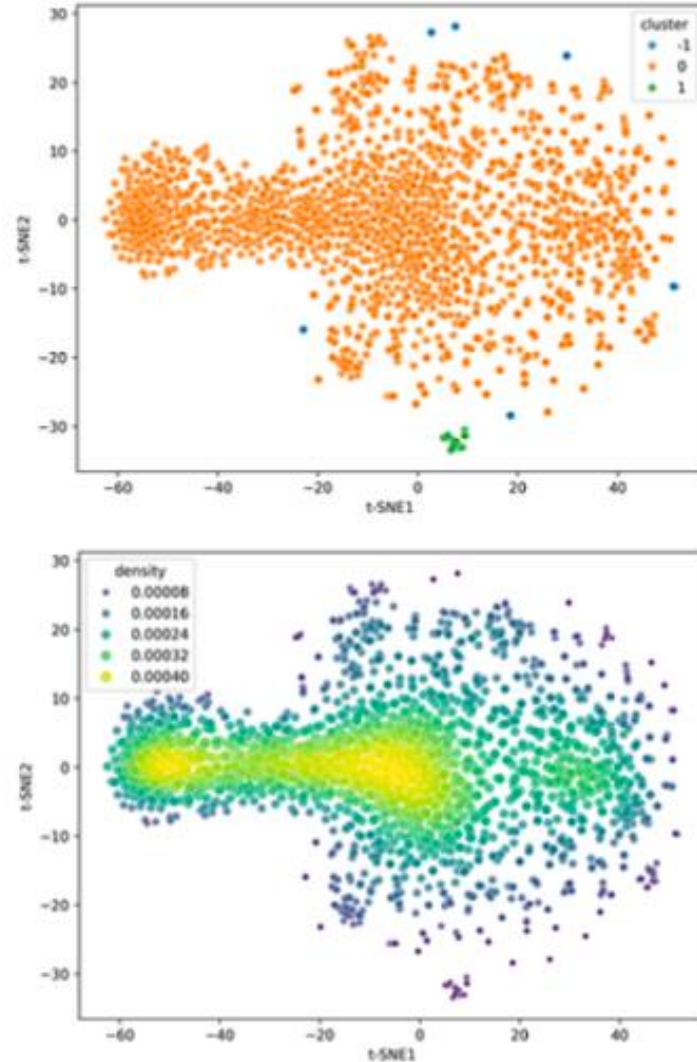
U-Net inspired architecture with dynamically (learnable) stored skip connections: **multi-scale** feature propagation across layers.

Clustering Results – METHOD better separates diversity in CA samples

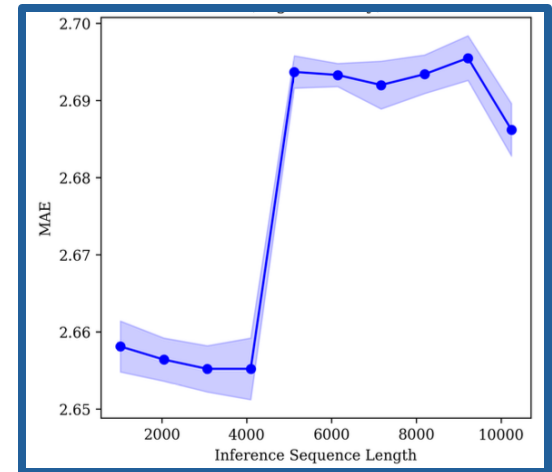
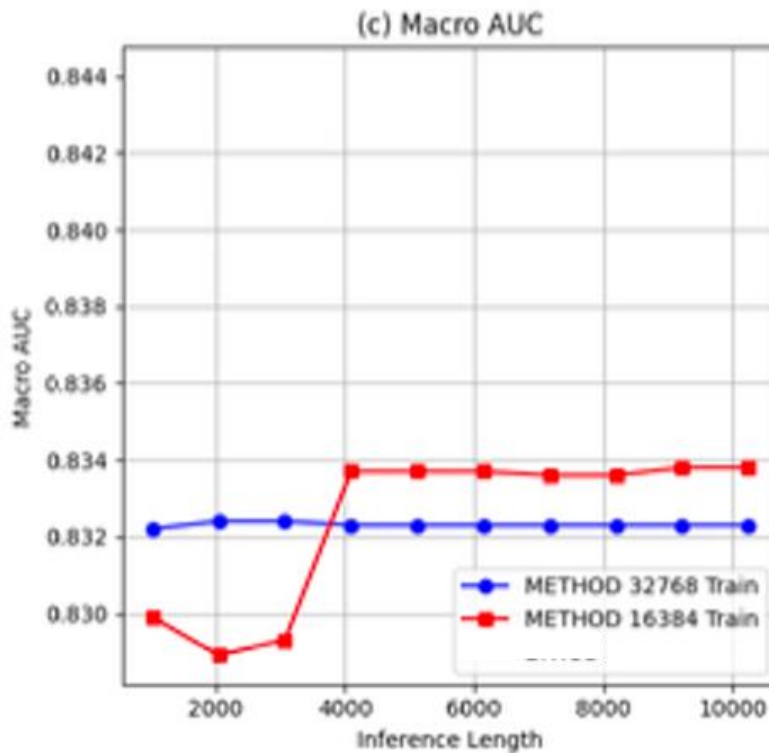
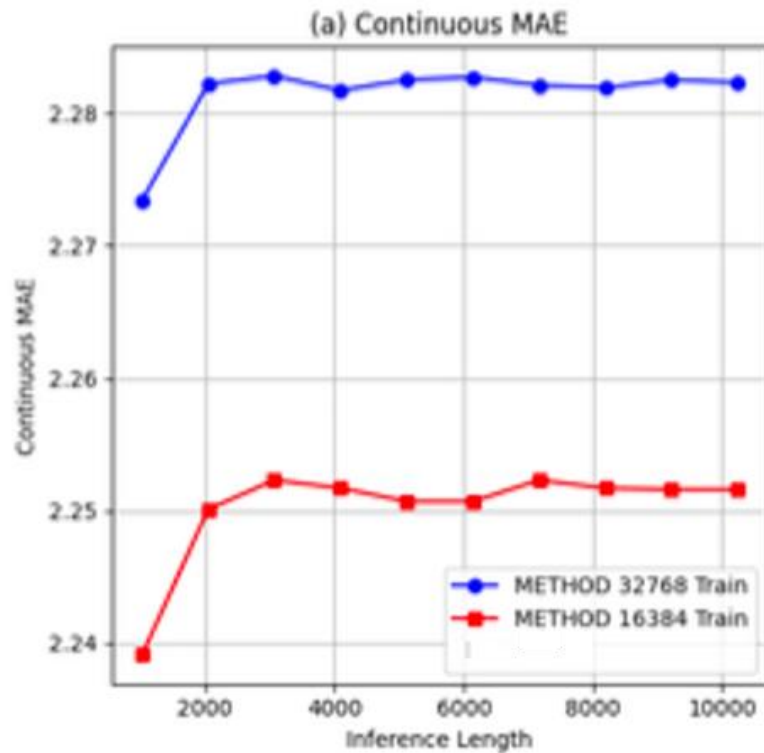
Foresight Clustering



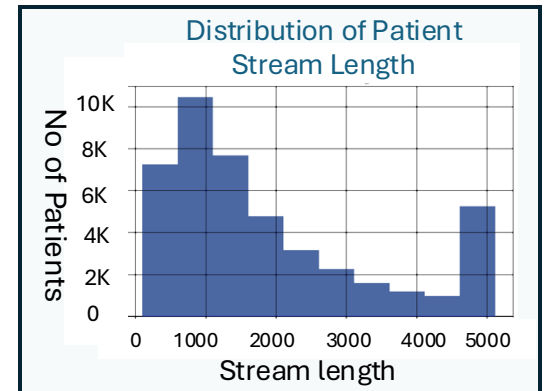
METHOD Clustering



Result: Impressive ability to use ‘short sequence’ data to perform inference

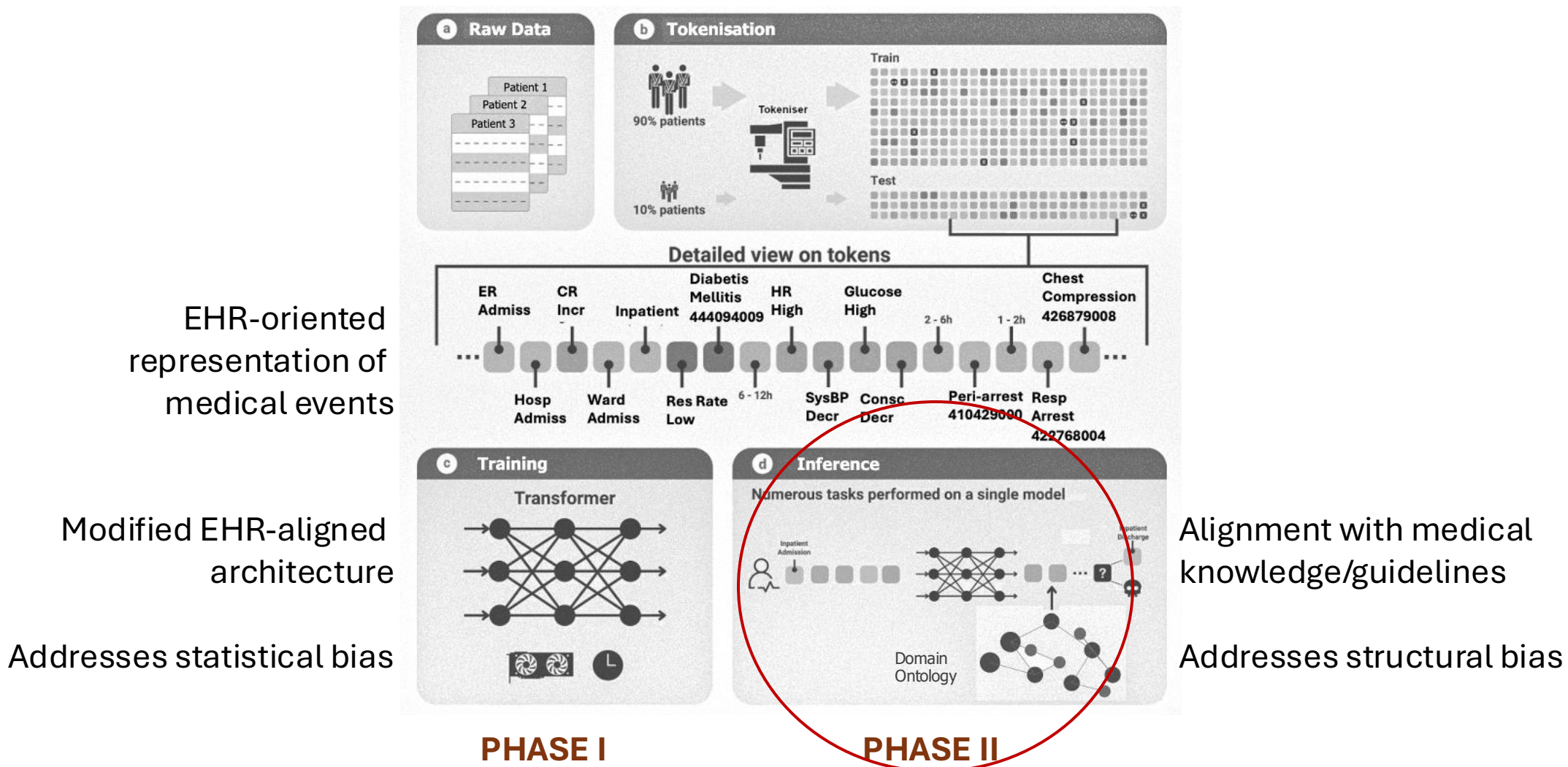


FORESIGHT

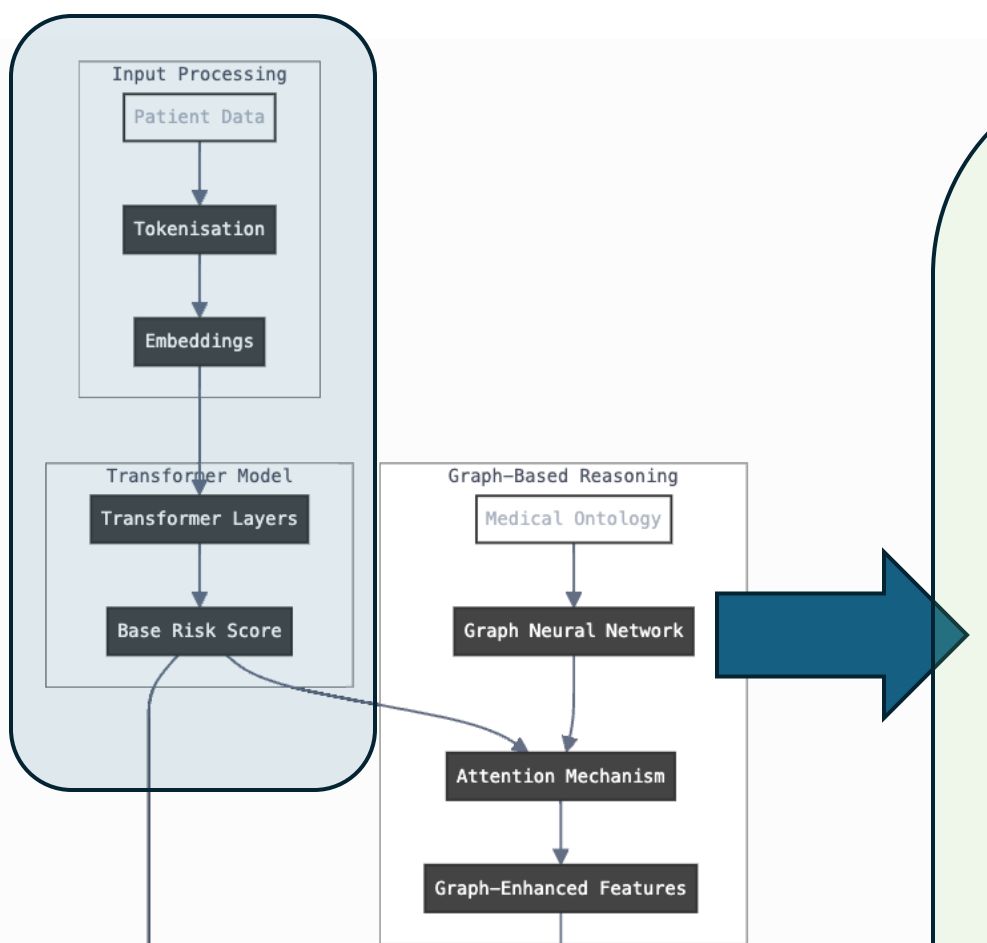


Distribution of CUI Streams per Patient @KCH

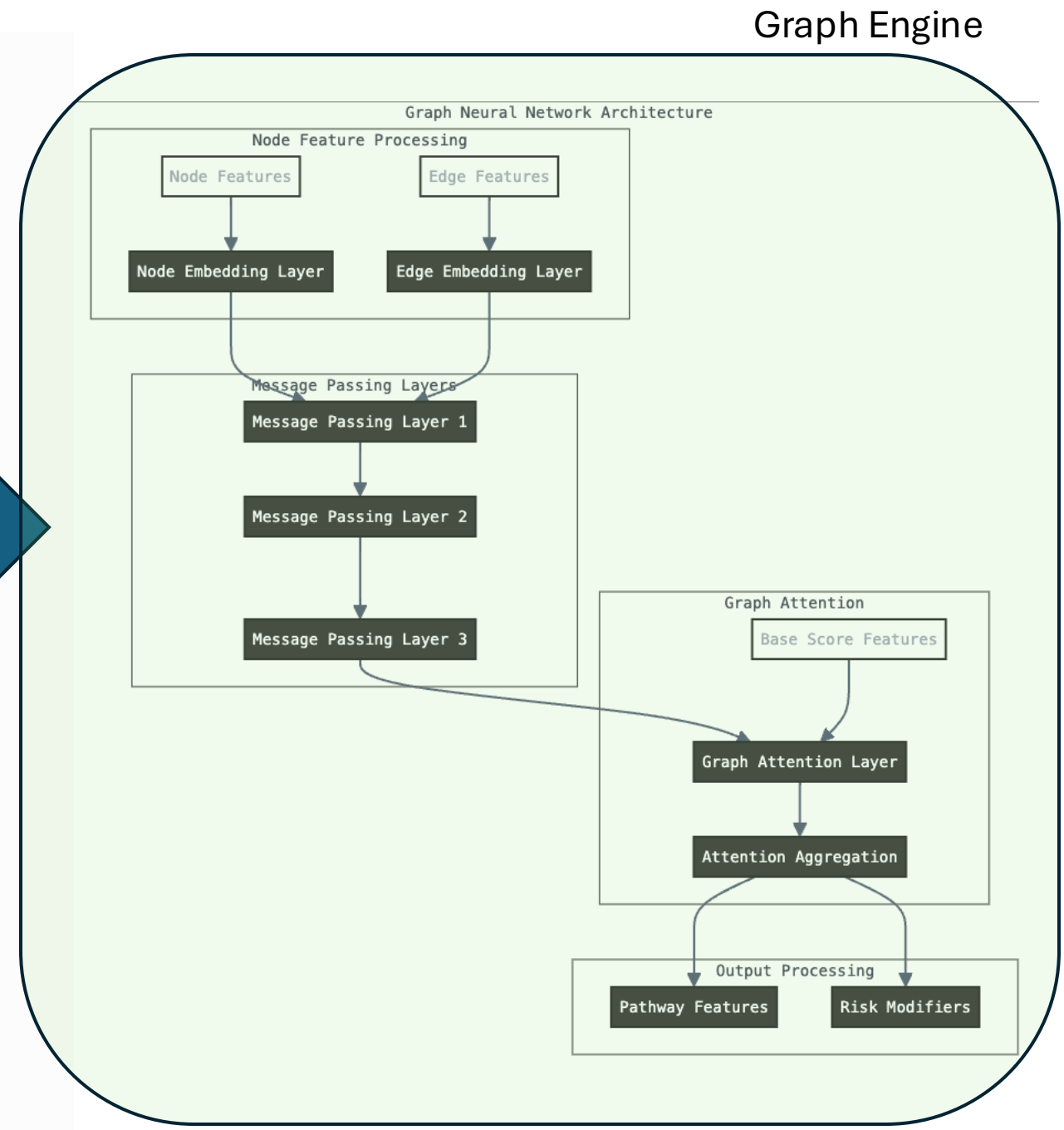
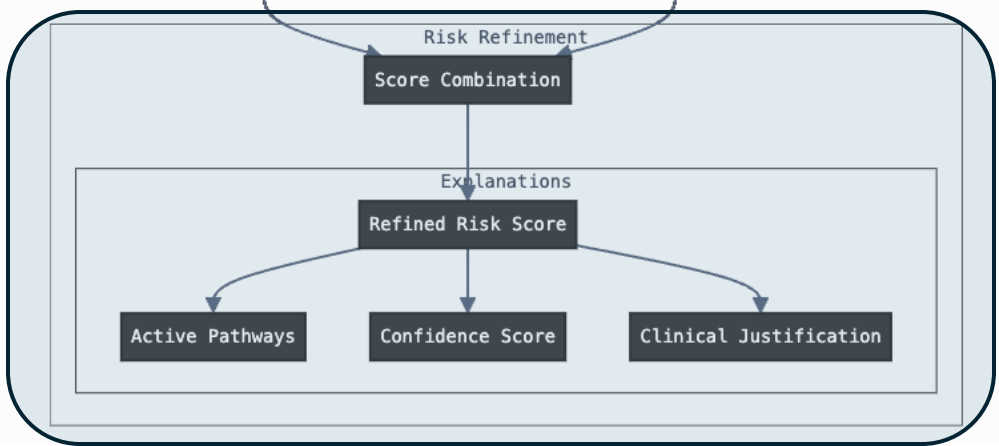
Our Solution – METHOD: Modular Efficient Transformer for Healthcare Outcome Discovery



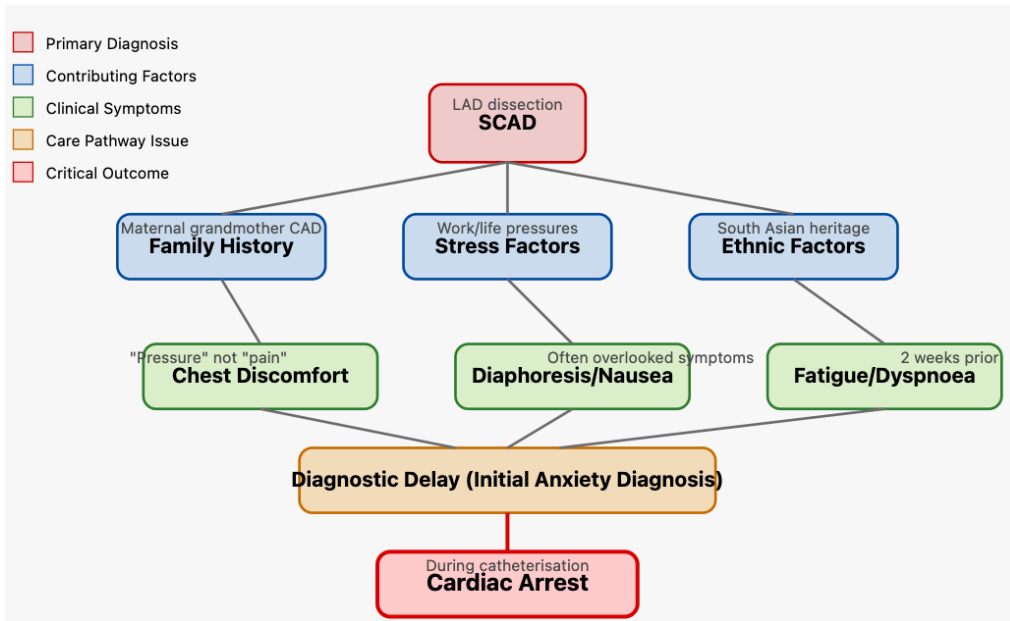
Phase I



Phase II



Sample Case Analysis



- 32-year-old South Asian female
- No prior cardiovascular history
- BMI: 23.4 (normal range)
- Non-smoker, social alcohol use
- Regular yoga practitioner (3x weekly)
- Family history: Maternal grandmother with premature coronary artery disease (age 49)
- **Presenting Symptoms**
 - Sudden onset chest discomfort (described as "pressure" rather than pain)
 - Fatigue and dyspnoea for 2 weeks prior
 - Initially dismissed by primary care as anxiety/stress
 - No classic male-pattern radiation of pain
 - Diaphoresis and nausea present
 - Initial ECG: Subtle ST-segment elevation in anterior leads
 - Initial troponin: Borderline elevated (0.08 ng/ml)



Take-home Messages

- Off-the-shelf Transformer architectures are less than ideal for EHRs
- Talk to me about:
 - Data-driven (generative) models are not the best we can do!