Implementation of foundation models in the Trøndelag Health Study

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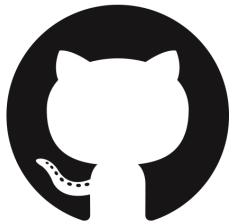

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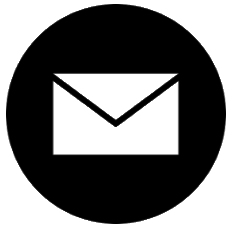

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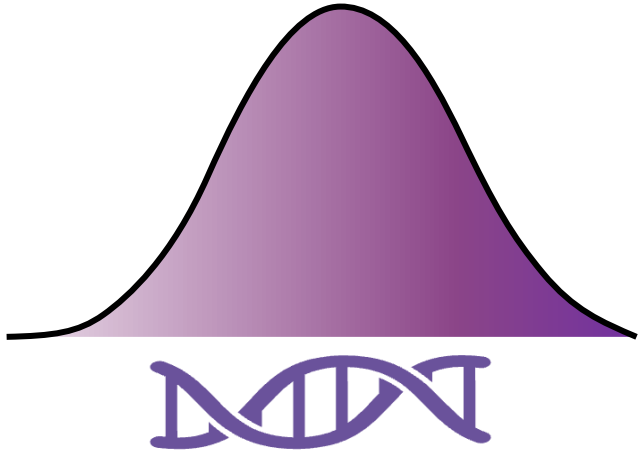
Improving cardiometabolic disease risk prediction for precision public health

Conventional risk models



Polygenic score
(PGS/PRS)

EHR-based
Clinical Risk Score

Average risk

Your risk

Intervention

The Trøndelag Health Study (HUNT) population-based biobank

- Regional hospital system for EHR
- High participation (54-89%)
- Genetically homogenous
- Low emigration rates (<3%)
- Linkage to national registries
- Longitudinal questionnaires

Næss, Int J Epidemiology, 2024
Brumpton et al, Cell Genomics, 2022
Åsvold, Int J Epidemiology, 2022

Store Norske Leksikon

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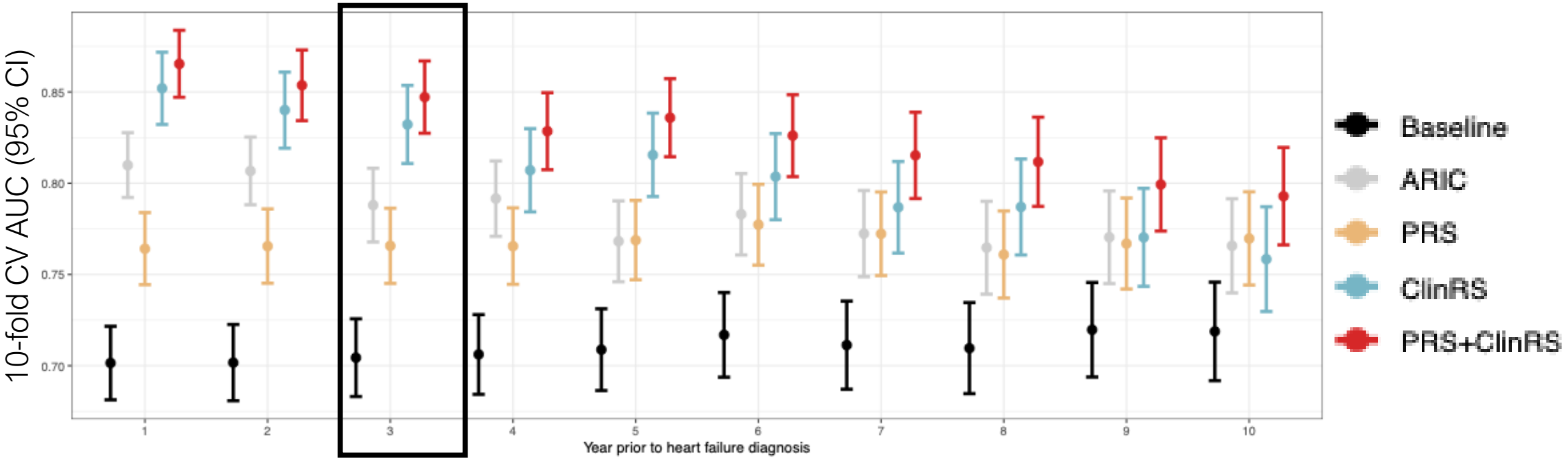
Motivation: Additive model with genetic and clinical information performs better than ARIC-HF Score 3 years before diagnosis



Year prior to heart failure diagnosis

Baseline: Age, Sex
ARIC HF Risk Score: age, race, gender, prevalent CHD, systolic blood pressure, use of BP-lowering medication, diabetes, smoking status, heart rate, BMI
PRS_{HF} from GBMI (Zhou et al, Cell Genomics, 2022)



Wu et al, Communications Medicine, 2025

Kuan-Han Wu Xu Shi Cristen Willer

How does a foundation model trained in the US perform in predicting heart failure in Norway?

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Foundation models pre-trained on health data

CLMBR: Clinical Language Modeling Based Representations (Steinberg et al, 2021, Wornow et al, 2023)

141 million parameter autoregressive foundation model pretrained on 2.57 million deidentified EHRs from Stanford Medicine

MOTOR: Many Outcome Time Oriented Representations (Steinberg et al, 2024)

Time-to-event (TTE) 143M parameter foundation model which is pretrained on timestamped sequences of events in 55 million electronic health records (EHR) comprising 9 billion clinical events.

Delphi-2M (Shmatko et al, Nature, 2025)

Extended a generative pretrained transformer model trained on data for more than 1,000 diseases and baseline health information recorded in 402,799 UK Biobank participants

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Metric	St Olav's Hospital	Namsos & Levanger (HNT)
Unique patients	52,112	8,537
Original ICD records	778,128	11,137
Total events mapped	778,120	11,122
Conversion rate	99.99%	99.87%
Final SNOMED CT records	785,202	12,000
Full cohort demographics		
Total unique patients		54,675
Female participants		46,883 (53.1%)
Median birth year (IQR)		1956 (1941–1971)

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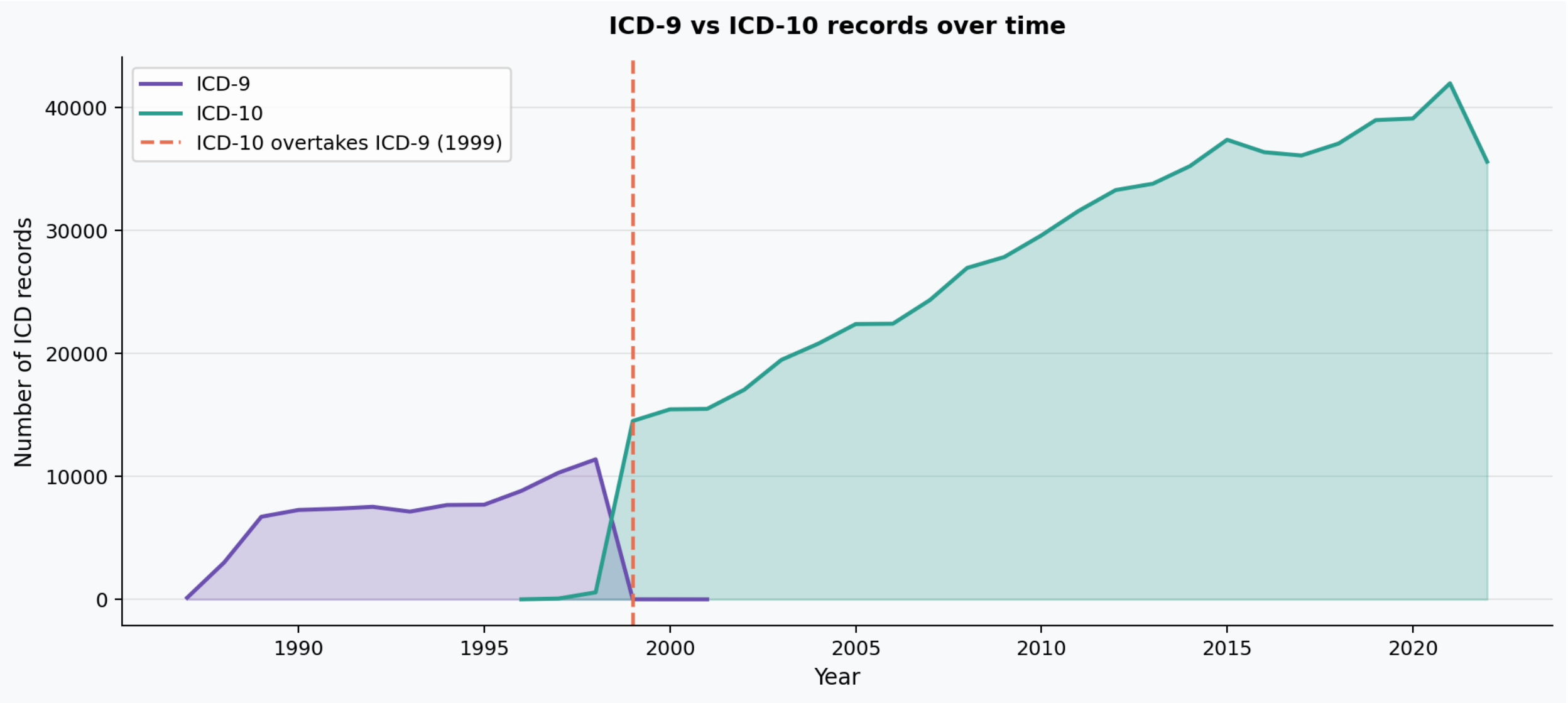

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Processing the Electronic Health Record in the HUNT study

Structured EHR data from 1987-2024
Primary and secondary diagnoses from 3 hospitals

Juan Martínez Urdaci
Erasmus student

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Tabular International Classification of Disease (ICD) codes for 88,000 participants

SNOMED CT
The global language of healthcare

ATHENA

Conversion to OMOP CDM standardized vocabulary

Shah Lab

Medical Event Data Standard

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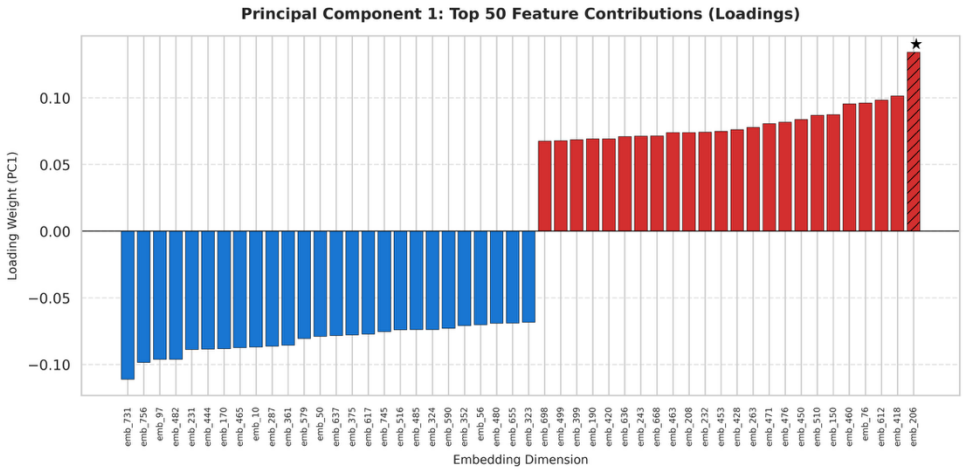
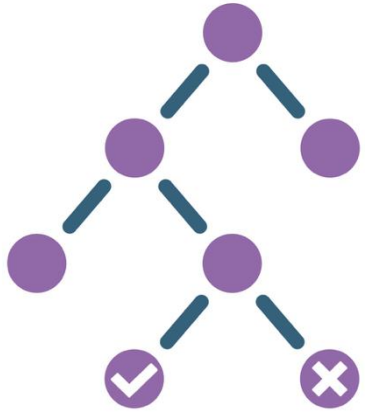
1. Implement MOTOR

Stanford MEDICINE

2. Extract embeddings



3. Perform binary classification



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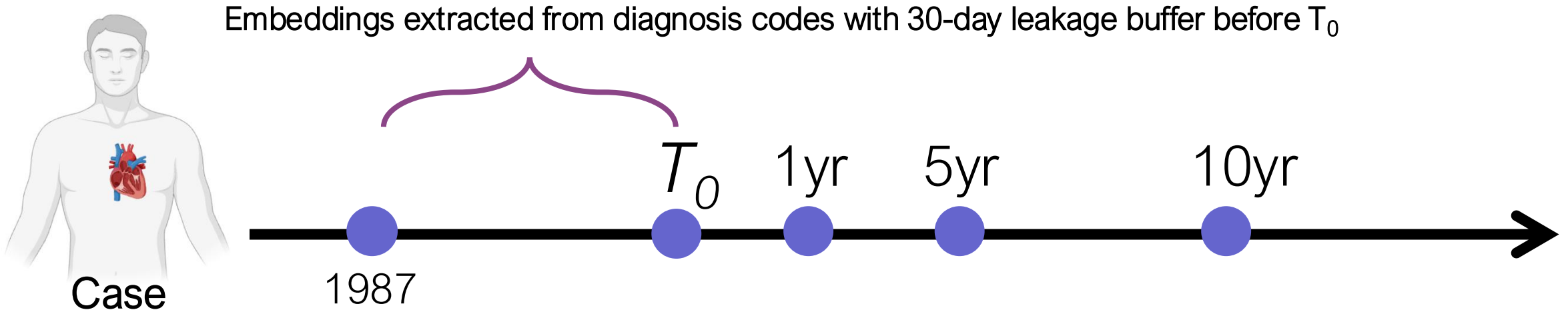
Classifying heart failure at time horizons



Horizon	ROC-AUC (95% CI)	PR-AUC	Prevalence	Cases
1 year	0.80 (0.78,0.81)	0.033	0.0084	398
5 year	0.79 (0.78,0.81)	0.054	0.0139	664
10 year	0.77 (0.76,0.79)	0.056	0.0170	809

47,608 without prior HF diagnosis

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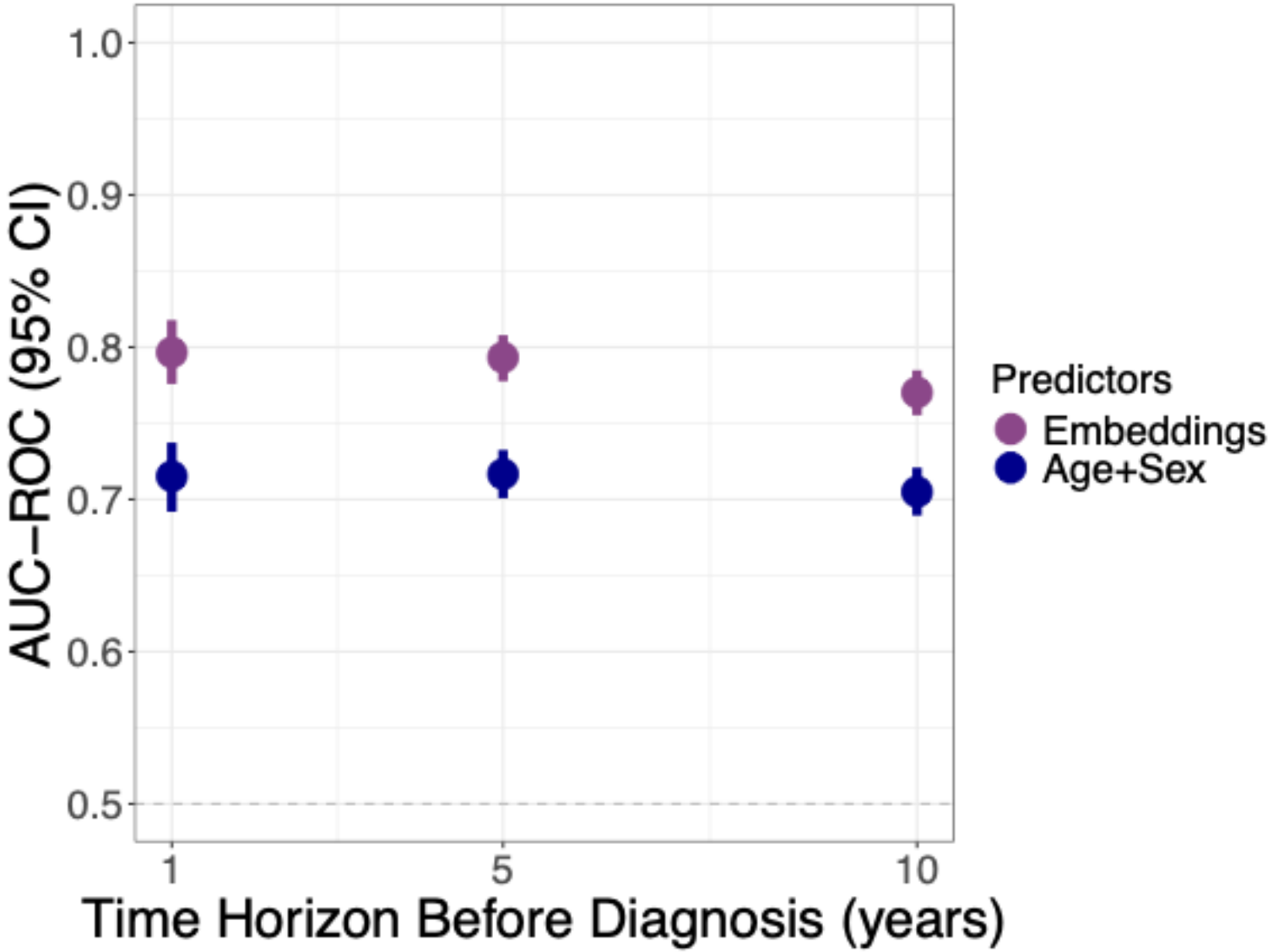
Prediction of heart failure using embeddings from a US-trained foundation model



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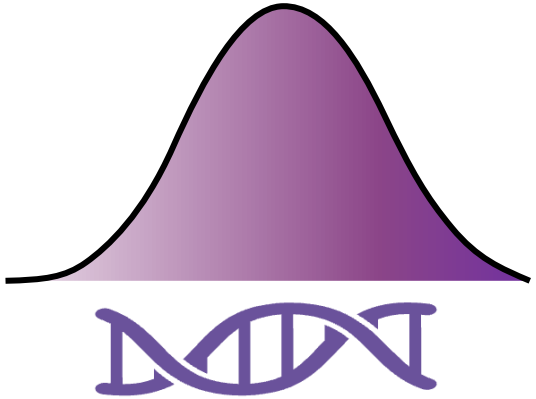
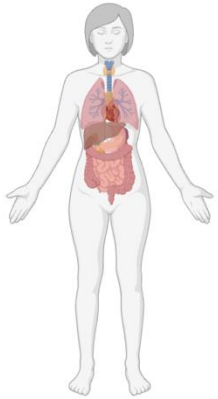
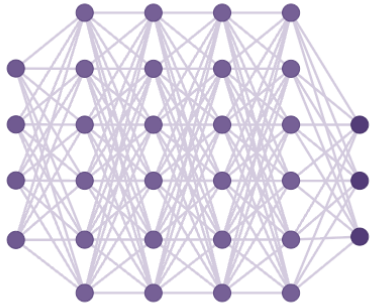
Future directions

- Inclusion of prescription registry, procedure codes, and lab values
- Addition of polygenic risk scores
- Prediction of additional traits
- Benchmarking of other foundation models







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