

CDS CHALLENGES AND SOLUTIONS: THE KNOWLEDGE ENGINEERING PROCESS FOR IMPLEMENTING FHIR AND CQL FOR THE STRATIFY AHF RISK ASSESSMENT TOOL

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INTRODUCTION

With the rise of complex clinical processes and the need for interoperable Clinical Decision Support (CDS) systems, **FHIR** (Fast Healthcare Interoperability Resources) and **CQL** (Clinical Quality Language) have emerged as pivotal standards for ensuring efficient data integration and sharing.

Vanderbilt University Medical Center (VUMC) has leveraged these frameworks to develop the **STRATIFY AHF Risk Prediction Tool**, a SMART on FHIR app designed to identify patients with acute heart failure (AHF) at low risk of 30-day mortality or complications.

KNOWLEDGE REPRESENTATION CHALLENGES

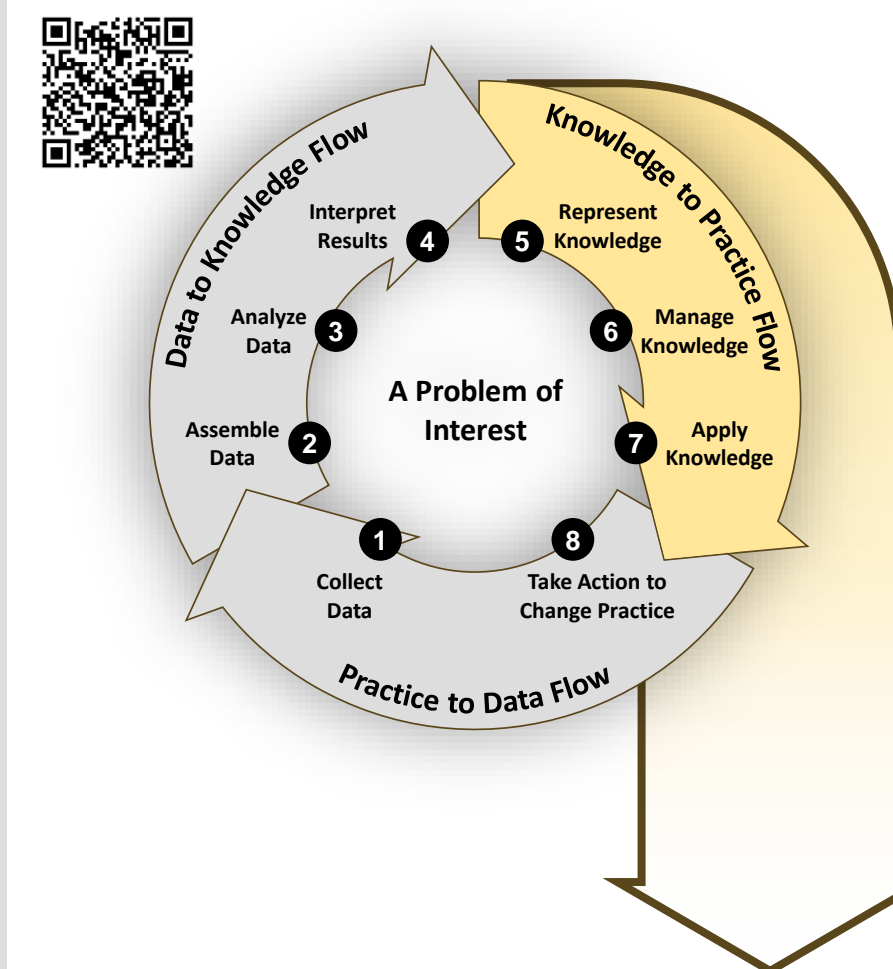
- **Creating a precise, centralized, authoritative knowledge base (KB)** that represents heterogeneous concepts with rich metadata and lineage, ranging from informal requirements to standard-based executable code
- **Soliciting shared abstractions with SMEs** (e.g. QRS concept, LOINC:8633-0 and LOINC:44973-6, QRS Duration lab build item in the EHR, Has_Prolonged_QRS input to the risk calculator)
- **Identification of clinical concepts** referenced by the CDS require clinical terminology expertise
- **Cross referencing terminologies with the EHR** build components requires thorough validation
- **Exposing a rich knowledge graph** for stakeholders for navigation, exploration, validation and curation
- **Creating and maintaining ETL** (Extract, Transform, Load) code implementations importing content from many data source systems
- **Maintaining accurate and up-to-date knowledge assets** for which the source data may change daily, but also need SME approval before each update can be used in the CDS implementation

ACKNOWLEDGEMENTS

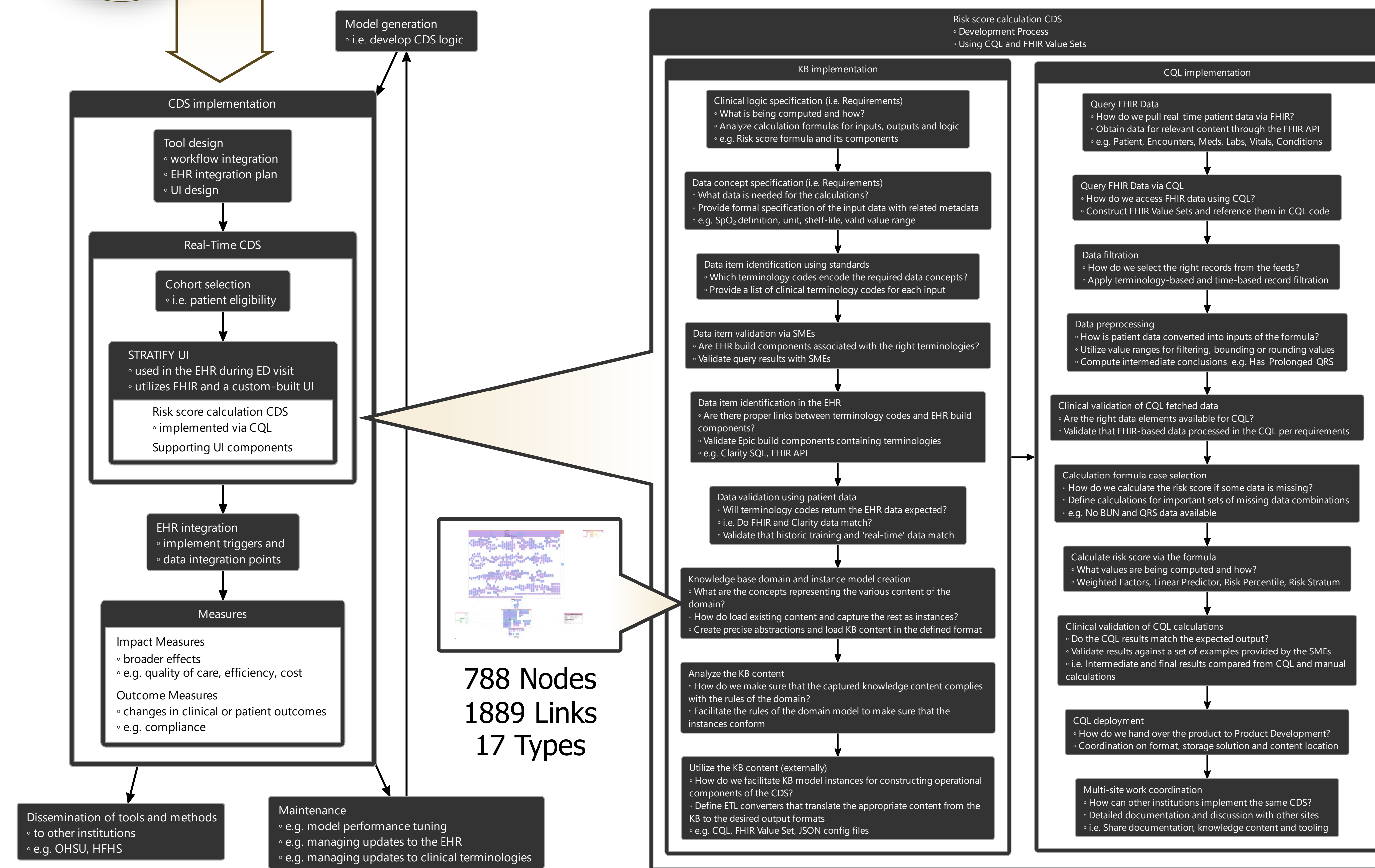
To all STRATIFY team members, see list at <https://www.vanderbiltem.com/stratify>



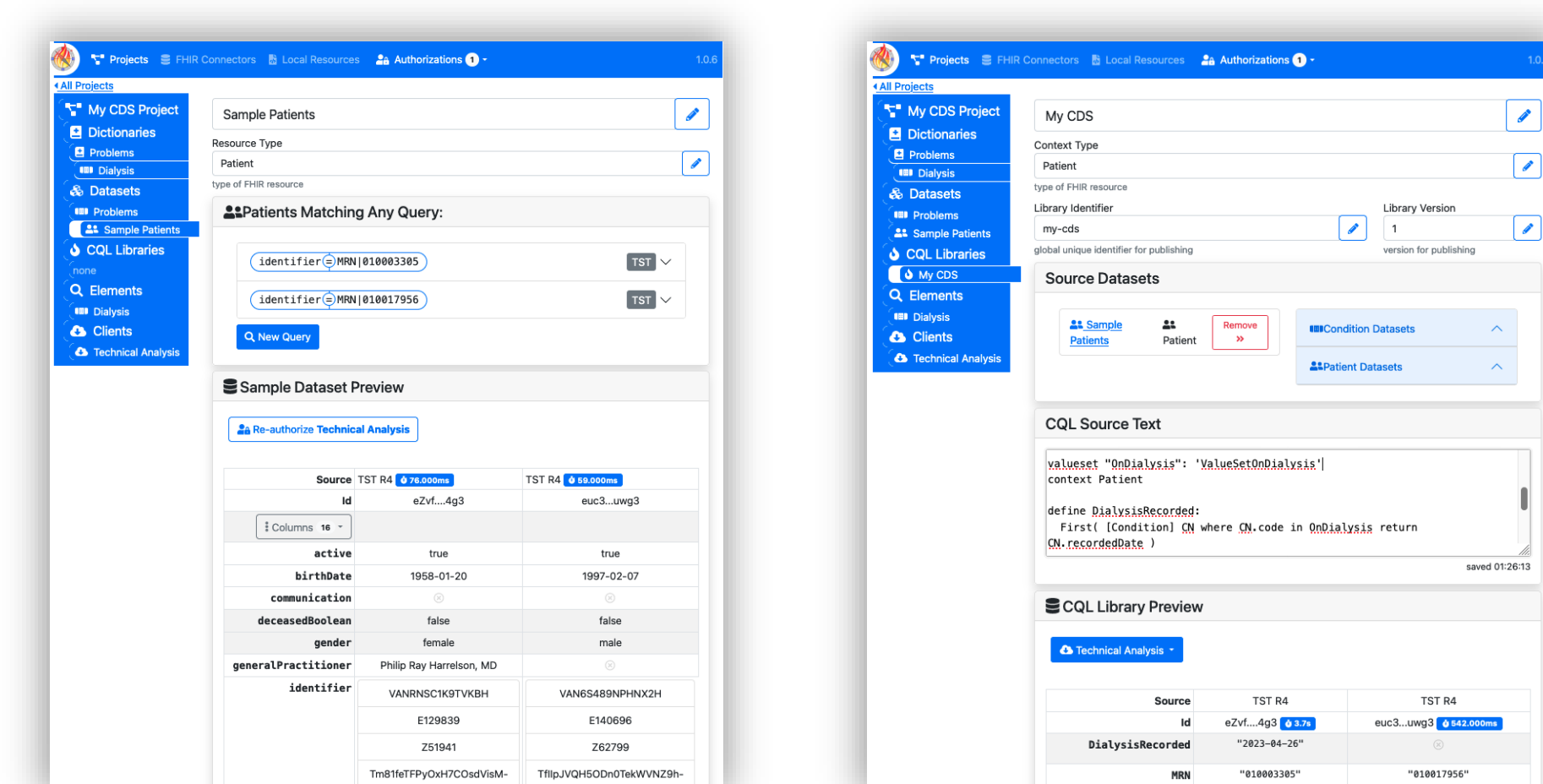
METHODS: PROJECT IMPLEMENTATION PROCESS



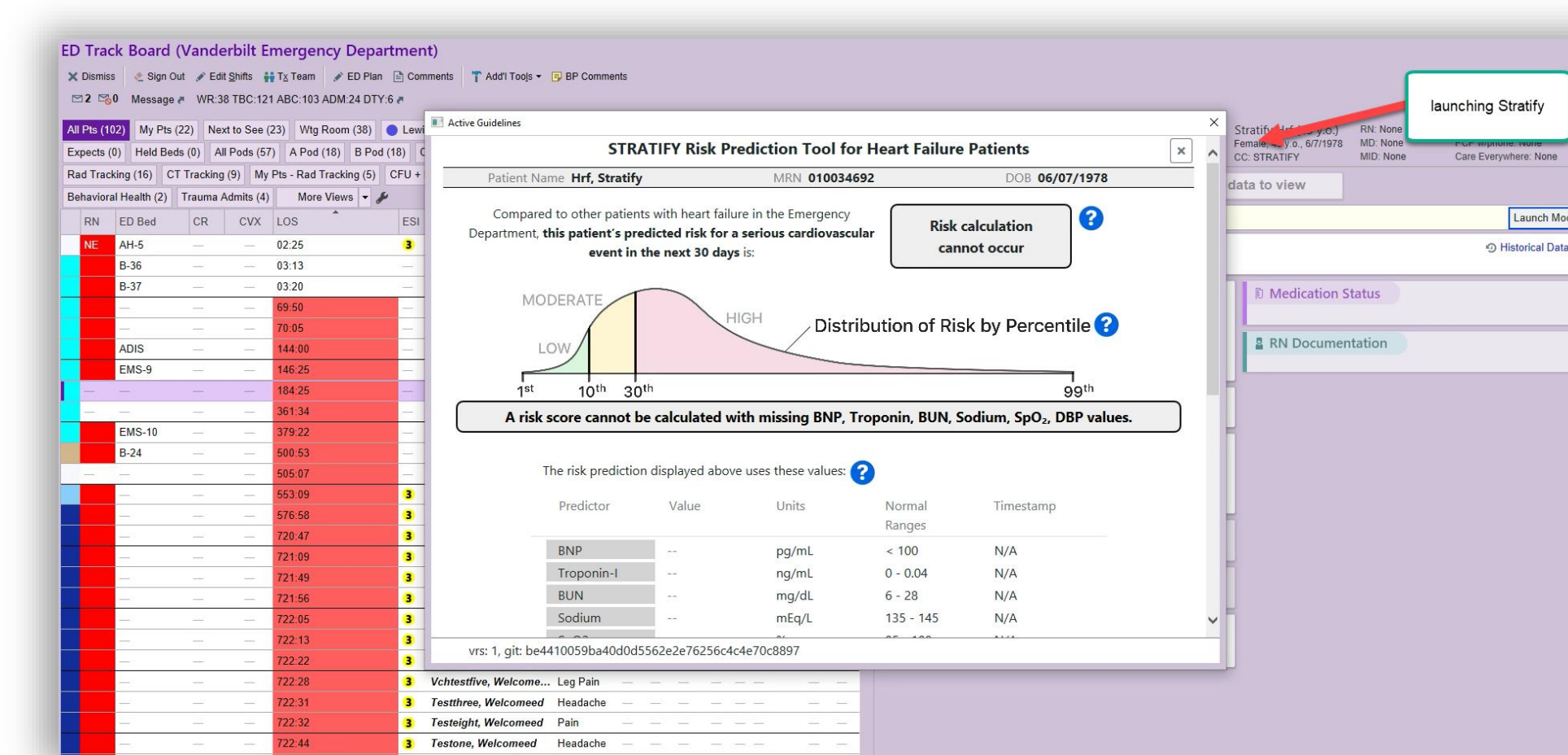
We created a coordinated set of **standard-based CDS artifacts** to implement the risk calculation formula for STRATIFY. The artifacts include the CQL implementation of the fetching of the data from the EHR, and the calculation of the AHF risk score. The clinical concepts providing the input data for the logic are identified with the help of standard-based medical terminologies, including LOINC, RxNorm and ICD-10 and are packed as FHIR value sets for operation.



FHIR and CQL data lookup in the VUMC CQL Platform



STRATIFY AHF Tool invoked in the EHR



FHIR & CQL CHALLENGES

- **CQL interpretation and execution issues**, i.e. the execution engine does not implement every CQL feature fully (e.g. missing Array and Tuples concepts)
- **CQL language maturity issues**, such as missing language constructs (e.g. time zone conversion), poorly implemented type conversion, missing documentation examples, inability of sentence-like expressions to facilitate variables (e.g. "Now() - 2 hours" vs "Now() - OffsetValueVariable hours")
- **CQL development issues**, e.g. visualization of complex result sets, comparing multiple patient records for recognizing patterns, understanding query performance and timeouts, debugging error messages
- **CQL Platform usability issues**: since the tool was codeveloped with the AHF project, a lot of features were only added gradually (e.g. examining the JSON payload and error handling, which were critical for error handling) and other features are still needed

CONCLUSIONS

CQL and FHIR are instrumental and effective platforms for implementing interoperable CDS in modern EHRs. However, there are several key considerations:

- Implementing a tool with complexity comparable to our project **demands substantial knowledge engineering** to ensure clinical accuracy and maintainability.
- Establishing a production-ready solution **necessitates advanced technical expertise**.
- Due to the incomplete implementation of CQL specifications by existing engines, and inherent limitations within CQL itself, there are **restrictions on both expressivity and brevity**. These limitations may necessitate workarounds, which could obscure the original logic.
- To address the lack of features for efficient CQL development and testing in available tools, **we created** dedicated software to bridge this gap. The resulting **VUMC CQL Platform** has applications extending beyond the AHF project.