A novel approach to combine structured and narrative data annotation to improve EHR navigation: a demonstration study using OMOP.

Nicholas A. Timkovich, MSHI; Tiago K. Colicchio, PhD, MBA; John D. Osborne, PhD; Kaiwen He, MSc; James J. Cimino, MD
Department of Biomedical Informatics and Data Science, University of Alabama at Birmingham

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Introduction

The modern EHR system has notorious limitations regarding data retrieval and entry, system navigation, and providing assistance to clinicians to reduce cognitive burden when assessing a patient's medical history and current situation. To begin addressing these limitations, we are designing and prototyping a novel "**Patient-Specific Knowledge Base**" (PSKB) system in which a Clinical Context Ontology (CCO) is applied to text notes and structured EHR data to create a "Knowledge Base" of clinical reasoning for each patient. The "reasoning" information is represented as three-part "***Tuples***" in which "**[Concept 1] – [has a relationship with] – [Concept 2]**", and is designed to handle both free text annotations from clinical notes as well as structured data from the EHR. While other systems exist to manage and summarize note-based information, the mixed text and data approach of the PSKB is novel and has the potential to encapsulate a significant portion of the clinical record.

The clinician-facing User Interface of the PSKB is centered around a chronological **Timeline** that shows how interventions, observations and note-based concepts, all displayed as items on the timeline, are related to Conditions, displayed as horizontal "lanes" (**Figure 1**). The Timeline offers extensive filtering and sorting options, allowing the clinician-user to view the patient record from multiple perspectives and offers navigation links to the EHR note that contains the concepts that drive the timeline and illustrate the patient's history and conditions.

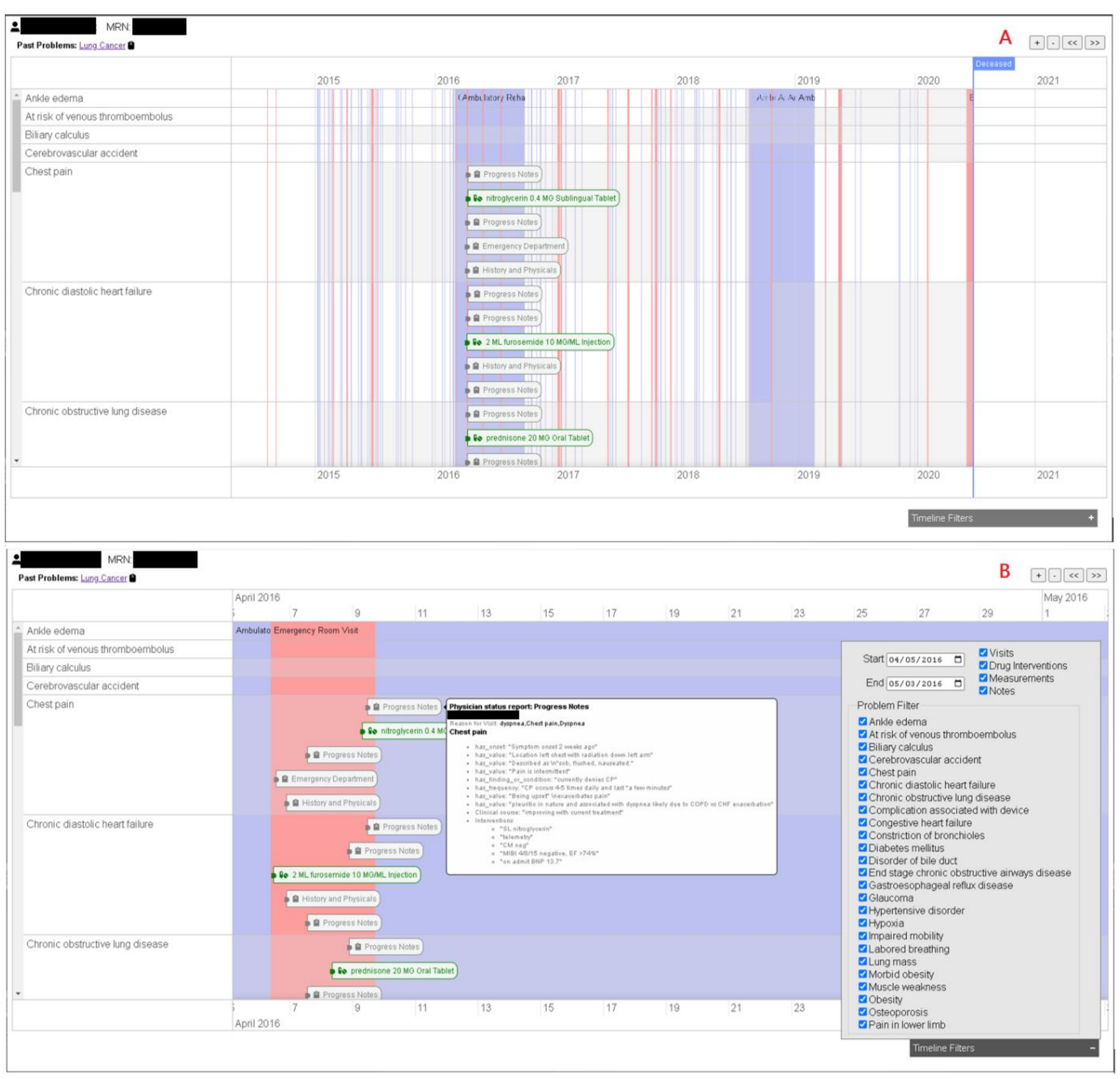

Figure 1. Our navigation tool displaying data from the PSKB created using the PSKB Tuple Editor. A) shows the overall timeline of the patient spanning multiple years with the shaded areas in the rows reflecting the period of time that each condition was active and the vertical bars indicating patient encounters over time. B) shows the same timeline with a zoomed in view for details about a specific visit. Note: identifiable information has been redacted, and dates were shifted to preserve patient privacy.

Methodology

In the initial phase of the PSKB project, to create a set of sample Tuples based on real patient data and to validate the contents of the Clinical Context Ontology, annotations were created by two authors (TKC, JJC) to identify reasoning statements and assign relationships from our CCO to link concepts from the patient's record including text mentions from clinical notes (e.g., reason for a drug prescribed) and structured data (e.g., drug orders, problems). The manual approach was completed using Microsoft Excel, then the records were imported into OMOP v5.3 tables stored in an Oracle DBMS.

As an automated, AI-driven approach was tested and implemented to create Tuples, the volume of records exploded and the need for an efficient method to review those Tuples became paramount. Additionally, **the human process to create Tuples using spreadsheets was inefficient, taking two subject matter experts approximately 14 hours to process 2 notes from just one in-patient visit.** This increased volume of data and trouble with the manual process drove the project team to create an effective UI for users to review and edit Tuples in the PSKB system.

The "**PSKB Tuple Editor**" web application (**Figure 2**) allows the user to select a Patient, then manage all relevant PSKB information in a single screen. The PSKB Tuple Editor was developed and evaluated by the project team, including an iterative design approach to improve usability and functionality. The web application is built on Microsoft's ASP.Net Core technologies, using the MVC pattern and an integrated Web API for server-side processing. The front-end uses Razor for markup generation, Bootstrap for styling, and the Knockout.js library for client-side data and event binding.

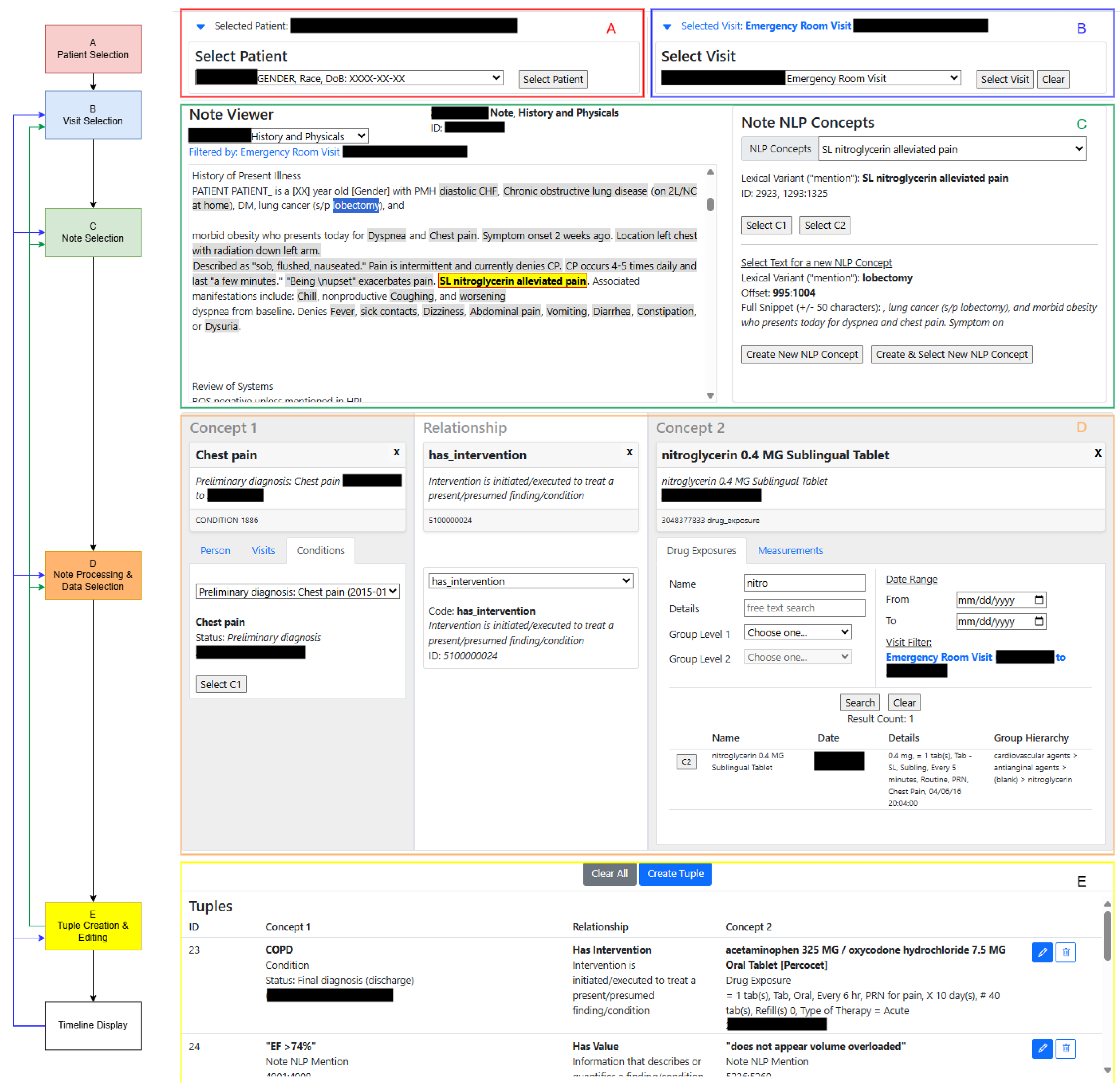

Figure 2. Example of the PSKB Editor being used to create a tuple linking the order "nitroglycerin 0.4 MG Sublingual Table" to the problem "Chest pain" from the patient's problem list. The reasoning for linking both concepts is explicitly stated in the note selected in the "Note Viewer" section. Box A (red) shows the patient selected. Box B (blue) shows the visit selected. Box C (green) shows the note selected. Box D (orange) shows the tuple currently been created. Box E (yellow) shows the tuples already created for this patient (first tuple displayed links the problem "COPD" to the order "acetaminophen 325 MG / oxycodone hydrocodone 7.5 MG Oral Table", the second tuple links the NLP mention "EF > 74%" to the other NLP mention that states "does not appear volume overloaded").

Results & Conclusion

To evaluate the new tool, the project team used the PSKB Tuple Editor to re-create the existing tuples for 2 notes during one visit and then processed 3 additional notes for the same visit. **The time to create and view tuples drastically decreased from 14 hours to 3 hours and 42 minutes**. The project team members using the tool reported much higher satisfaction and ease-of-use compared to the manual process.

We have demonstrated the implementation of a novel tool called PSKB Tuple Editor, which allows rapid annotation of structured data elements and text mentions from clinical notes, turning implicit statements about patient's care context into tuples. Although several annotation tools have been developed primarily to support NLP research to the best of our knowledge, no annotator currently available provides functionality to link together structured and narrative data.

- **The new Tuple Editor web application increases the efficiency of managing tuples by reducing the time to annotate a clinical note and producing Tuples and increasing the accuracy of the Tuples.**
- **The Tuple Editor and PSKB data structure has other potential uses, including supporting learning health systems and clinical decision support systems.**
- **Next steps include a formal usability study for the PSKB Timeline and Tuple Editor, and a pilot program with integration into the clinical workflow to evaluate overall benefit to clinical care and documentation.**

References

For further reading on the Patient Specific Knowledge Base project and Tuple Editor, please check the following publications:

- Colicchio TK, Osborne JD, Do Rosario CV, Anand A, Timkovich NA, Wyatt MC, Cimino JJ. Semantically oriented EHR navigation with a patient specific knowledge base and a clinical context ontology. AMIA Annu Symp Proc. 2024 Jan 11;2023:309-318. PMID: 38222434; PMCID: PMC10785934.
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