# Translating Electronic Clinical Quality Measures to Executable, Portable, and Customizable Workflows in KNIME

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## Introduction

The wide-spread adoption of Electronic Health Records (EHRs) has led to the development of a range of electronic clinical quality measures (eCQMs),[1] as well as EHR-driven phenotype algorithms for clinical research.[2] Such quality measures and phenotype algorithms are typically developed at a single site and then ported across multiple sites.[3] To facilitate this process, it is necessary to adopt an unambiguous formal language for algorithm representation, such as the Office of the National Coordinator (ONC)-sponsored Quality Data Model (QDM).[4,5] However, there is currently no widely available mechanism for translating QDM-based specifications into executable workflows that can operate on local EHR data, making the porting process difficult, time-consuming, and error-prone.[6] As part of the Phenotype Execution Modeling Architecture (PhEMA) project,[7] we are addressing this gap through the creation of a translator from QDM-based specifications to executable workflows for use with the open-source Konstanz Information Miner (KNIME) data analytics platform.[8] These workflows are easily shared across multiple sites, can be connected to local repositories with varying data structures, and allow for customization to account for heterogeneous local EHR data.[9]

## Methods

The input format to our translator is the JSON representation of QDM originally developed for Project Cypress, a tool for testing eCQM validity.[1] The translation target is KNIME, which offers a user-friendly graphical user interface with workflows represented graphically. Graph nodes represent data transformations, and graph links represent data flow (Figure 1). Our QDM2KNIME translator has three parts. First, it provides a near-complete collection of reusable KNIME nodes based on standard QDM elements and attribute sets, covering data types, temporal relationships, logical operations, and aggregative functions. Second, it provides a Java API for the stepwise construction of KNIME workflows for different translators and web applications. This includes the creation and setup of KNIME nodes, connections between them, and other necessary parts of the workflow. Third, it provides functionality for converting Cypress patient test data into a tabular format to test eCQMs inside of KNIME. We used QDM2KNIME to convert 10 published eCQMs into KNIME workflows, and tested four of them (CMS30, CMS123, CMS126, CMS179) using the converted Cypress test patient data. In addition, two of the authors (HM, JAP), tested eCQM CMS30 on EHR patient data by translation from eCQM to KNIME and execution on two different institutional repositories (VU and NU).

## Results

Running the Cypress test data through the test eCQMs produced the desired results: all test patients were scored correctly with respect to each of the four selected eCQMs. This result provides us with basic validation that QDM2KNIME is generating executable workflows that faithfully represent the logic of their source specifications. A more stringent test of feasibility is to use actual EHR patient data from multiple institutions. Measure CMS30 was translated into KNIME and executed at both VU and NU. Implementation required each to configure the data access and mapping workflow nodes (Figure 1. The results broadly matched our expectations (scoring 80% and 85%, respectively). Further evaluation against gold standard data sets is planned for future work.

## Discussion

We have determined the feasibility of automatically translating QDM-based eCQMs into executable KNIME workflows that can be shared across institutions and appropriately customized to handle patient data from multiple, heterogeneous EHRs. Our next steps are to integrate the QDM2KNIME translation software with the full suite of PhEMA tools,[2] which includes a QDM-based authoring tool and the PheKB repository of phenotype algorithms.[2] This integrated tool suite will make it possible to author and share QDM-based eCQMs and algorithms across multiple institutions with far less effort than is currently required.

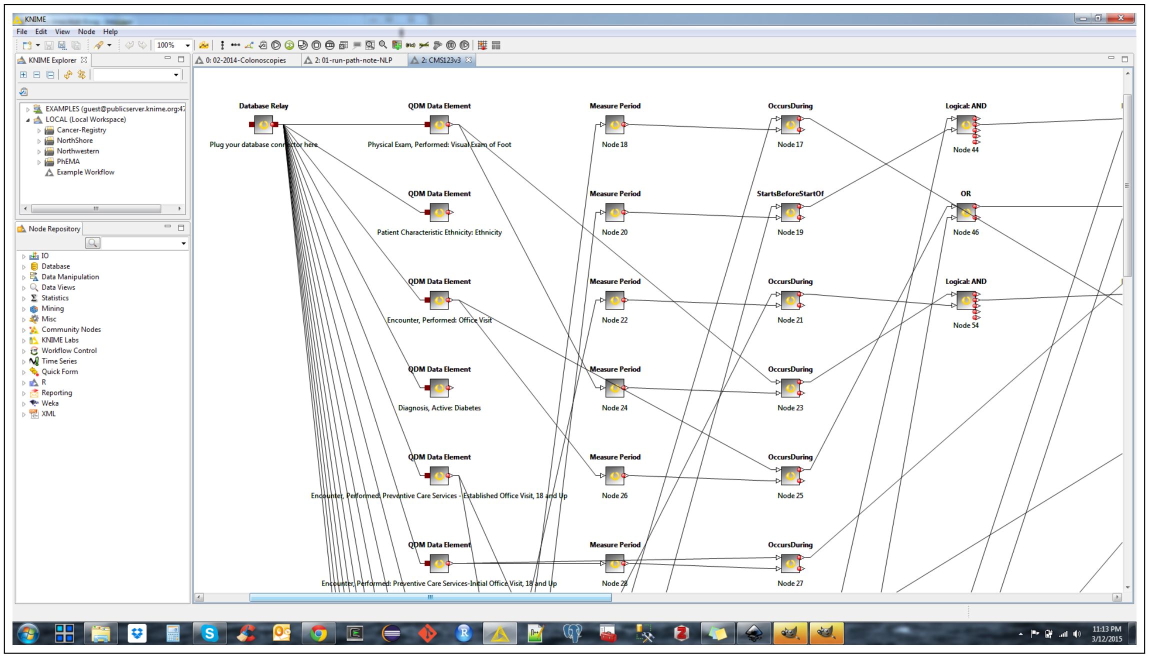


Figure 1: Implementation of CMS30 (Statin at Discharge) on KNIME.

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