Implementation Guide

Statin Therapy for the Prevention and Treatment of Cardiovascular Disease: Electronic Clinical Quality Measure

Agency for Healthcare Research and Quality
5600 Fishers Lane
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www.ahrq.gov

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Prepared by:

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Disclaimer of Conflict of Interest

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- Centers for Medicare and Medicaid Services (CMS)
- Quality Insights of Pennsylvania
- Patient-Centered Clinical Decision Support Learning Network
- MITRE CDS Connect Project Team

Record of Implementation Guide Changes

Date	Action	Notes
October 2017	Published *Implementation Guide*	
October 2019	Updated the *Implementation Guide* based on annual artifact updates	Updated the *Implementation Guide's* Introduction and Background content, revised the flow of the content to enhance readability, updated the evidence source, added evidence specifications and a semistructured representation of the artifact to Appendix A, and updated a small portion of the decision log.
April 2021	Updated the *Implementation Guide* based on annual artifact updates	Clarified how this differs from the Statin CDS artifacts, revised the flow of the content to enhance readability, updated text to indicate use of version 4 of the eCQM, and expanded CQL library details to account for the CQL updates related to eCQM v4 and FHIR R4.

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Introduction

Clinicians today face an unending stream of new research findings, new or updated clinical practice guidelines, and best practices identified by peers that they must incorporate into daily practice. Transforming these large volumes of research into actionable knowledge that can be integrated into clinical care is a lengthy and expensive process that stretches the limits of what any one healthcare system can reliably accomplish on its own. The CDS Connect project, sponsored by the Agency for Healthcare Research and Quality (AHRQ), provides an opportunity for healthcare organizations to share evidence-based knowledge expressed as clinical decision support (CDS), enabling other organizations to leverage the publicly available expressions. The ability to share CDS expressions enhances efficiency by removing the need for subsequent organizations to start CDS development from "scratch." It also contributes to a learning health community where CDS developers and implementers collaborate and enhance the shared resources.

The CDS Connect project team develops CDS artifacts (i.e., CDS logic expressions) and contributes the body of work to the CDS Connect Repository to demonstrate CDS Connect infrastructure and publicly share the CDS. Some of the artifacts developed by the project team go on to be piloted in a clinical setting. When this occurs, the project team includes a Pilot Report with the artifact to describe CDS integration, testing, and implementation details, along with end-user feedback. Future implementers can leverage the insight outlined in the report to inform their implementation.

Other artifacts, like this one, are published one step earlier in the CDS development process (i.e., they are published as a human-readable logic statement that aligns with an evidence-based source, as opposed to a computer-coded version of the evidence). Because these artifacts have not been fully coded, they have not been field-tested in electronic health record (EHR) systems or other technologies currently in use. However, the human-readable artifacts provide a valuable starting point for healthcare organizations that seek to develop CDS due to the sizeable amount of research and analysis that is required to translate narrative clinical practice guidelines into human-readable logic. CDS Connect artifacts are not "standalone" and are not intended to be completely plug-and-play; healthcare systems will need to integrate each artifact with components of their health information technology (IT) system for the artifact to work. Implementers should conduct extensive testing—including clinical testing in real-life workflows—of all artifacts. The project team expects that artifacts will be customized and adapted to local clinical and IT environments.

This Implementation Guide provides information and guidance to individuals considering their potential use of this artifact. The main intent of this document is twofold: 1) to provide insight on how the human-readable logic expression can be used to improve patient care, and 2) to provide information on how to transform the human-readable logic expression into interoperable logic code and integrate the CDS logic with a health IT system.

Background

To facilitate AHRQ's vision, the CDS Connect project team created—

- The CDS Connect Repository to host and share CDS artifacts.
- The CDS Authoring Tool, which enables CDS developers to create CDS logic using Clinical Quality Language (CQL), a Health Level 7 (HL7) standard expression language.
- Several open-source prototype tools to facilitate creating, testing, sharing, integrating, and implementing evidence-based, interoperable CDS in health IT systems.

The use of CQL in CDS Connect systems and CDS development provides the ability to express logic that is human-readable, yet structured enough to process a query electronically. Furthermore, CQL is an interoperable format that eases integration with health IT systems.[1] CQL allows logic to be shared between CDS artifacts, and eventually with electronic clinical quality measures (eCQMs), in support of improving healthcare quality.

The CDS Connect Repository hosts and shares CDS artifacts across a wide array of clinical topics. The Repository provides contributors with more than three dozen metadata fields to describe their work, including the artifact's purpose, clinical uses, publisher, sponsoring organization, reference material from which the CDS was derived, human-readable logic, and decisions made while creating the artifact. It also enables contributors to upload the coded logic expression, test data, technical files, and reports.

The CDS Authoring Tool provides a user-friendly interface for creating standards-based CDS logic using simple forms. The logic developed by the tool is expressed using HL7 Fast Healthcare Interoperability Resources® (FHIR) and CQL. It empowers organizations that have limited access to software engineers with the ability to express evidence-based guidelines as accurate, tested, and coded logic. Individuals who are interested in developing CDS logic expressions like this artifact can use the tool to develop new CDS logic in the clinical domain of their choice. The interoperable format of the logic facilitates sharing and integration with a wide range of health IT systems.

The CDS Connect team also developed several prototype tools, including one that facilitates CQL testing (CQL Testing Framework) and one that facilitates integration of the CQL code with a health IT system (CQL Services). The CQL Testing Framework allows CQL authors to develop and run test cases for validating CQL-based CDS logic. This framework allows CQL developers to identify bugs in the CDS logic early in the development cycle, when it is less costly to fix. In addition, these test cases enable developers to demonstrate the expected behavior of the CDS logic to bolster trust in the coded expressions. Vendors and integrators may also choose to use the CQL Testing Framework to test any site- or product-specific modifications to this artifact's CQL. CQL Services is an open-source service framework for exposing CQL-based logic using the HL7 CDS Hooks application programming interface. This capability allows implementers to integrate CQL-based CDS into systems that do not yet support CQL natively.

Scope, Purpose, and Audience of This Implementation Guide

This document provides information about the development and implementation of the Statin Therapy for the Prevention and Treatment of Cardiovascular Disease (CVD) eCQM artifact, referred to as the "Statin Use eCQM" artifact in this document. Various audiences may find this information helpful, including:

1. **Clinicians and Quality Leaders** at healthcare organizations and primary care practices who wish to implement, test, and execute CDS related to this topic in their health IT tools.
2. **Healthcare Systems** interested in promoting patient experience beyond traditional brick-and-mortar care to facilitate patient engagement and a patient's ability to manage their health, while enabling value-based care and quality.
3. **Employers and Payers** who want to manage their cost and quality through patient-facing CDS and health management tools.
4. **CDS Developers and Informaticists** who may use components of this CDS logic as a foundation for other preventive health CDS, or who want to use well-developed structured logic and CQL in their own work.
5. **Organizations or Individuals** interested in developing their own patient-facing CDS artifacts who may find this document helpful as a resource for the process by which clinical guidelines are translated into mature CQL artifacts.

Implementing and Using This Artifact

Artifact Description

This artifact provides statin therapy recommendations for primary and secondary prevention of CVD for patients considered to be at high risk of cardiovascular events. It is a CDS logic representation of clinical guidance expressed in a CMS eCQM (i.e., CMS measure identification (ID) CMS347v4, "Statin Therapy for the Prevention and Treatment of Cardiovascular Disease"),[2] which is in part based on 2013 Guideline on the Treatment of Blood Cholesterol to Reduce Atherosclerotic Cardiovascular Disease (ASCVD) Risk in Adults from the American College of Cardiology (ACC) and the American Heart Association (AHA).[3] Note that both primary and secondary prevention are included in this measure, yet the clinician- and patient-facing CDS artifacts for statin use cover only primary prevention.

Preventive Health Scenarios Supported by This Artifact

This artifact transforms the eCQM into clinical decision support by presenting it as a screening artifact. It checks a patient's record to see if they meet the denominator criterion for any of the three denominator-based subpopulations (see Evidence Source for Artifact Development section of this artifact). If they do, then the patient is not excluded or excepted; if the patient is not

already on a statin, the artifact recommends that the clinician consider ordering a statin drug. However, the CDS diverges from a component of the eCQM logic in one key aspect: the eCQM provides reasonable exclusions and exceptions for withholding a statin in unique patient cases, but a patient may not *need* to be excepted from statin therapy if the case is mild or resolved (e.g., resolved hepatitis A; mild liver disease that does not cause cirrhosis). Decisions made during artifact development to transform eCQM logic into CDS logic are highlighted in the Guideline Translation Summary section of this document and detailed in Appendix A.

In the following clinical scenarios, the decision logic and recommendations are expressed as an Event-Condition-Action alert (i.e., a condition-based alert reacting to a specific event). Each scenario is populated with a fictitious patient name and health data to provide context to the scenario.

1. **Any time a patient's record is opened by a clinician's direct action**
    a. Dr. Alpha is going through the records of his patients to be seen this afternoon, and is currently reviewing the record of Ms. Bravo, a scheduled patient. When the record is opened in the EHR, the CDS logic described herein executes to determine whether to recommend that Ms. Bravo begin taking statins. The relevant recommendations could appear immediately in a box on the EHR screen for the clinician's review and action, or could be posted to a "to-do" list visible in the patient's record.
2. **As automatic surveillance performed prior to the start of a clinician encounter (particularly in a primary care, cardiology, geriatric, or internal medicine practice)**
    a. Ms. Bravo arrives for a scheduled appointment and is registered into the encounter. This registration automatically triggers the CDS logic of this artifact. The logic delivers any recommendations as a message to the clinician's inbox or a "to-do" item in the patient's record.
3. **As automatic surveillance performed at a fixed time each night before the practice opens**
    a. Dr. Charlie's practice automatically runs a review each evening on all patients to be seen the following day. This review sets up face-sheets and requests charts for the intake personnel to use the next day. As part of this review, the computer scans each patient for several health maintenance gaps, including using this CDS artifact to check for appropriate use of statins. When the CDS logic determines that a patient merits a statin recommendation, the logic delivers the recommendation via an inbox message to the provider or a "to-do" item on the patient's chart. The recommendation can also be printed as part of the patient's visit face-sheet.

Preventive Health Scenarios Supported With Customization of the Coded Expression

Additional preventive health scenarios make use of the decision logic and recommendations in this artifact, but may require adjustments for a different workflow, type of user, or mode of operation. Example scenarios include:

1. **Population health:** Inclusion in a requested or periodic screening scan of an entire patient panel or population.
    a. Dr. Charlie's practice is running a quarterly quality screen to find patients in need of various health maintenance and promotion services. The CDS logic is run as a report for all patients in the practice. Recommendations for appropriate patients appear on each patient's individual "to-do" list and are also compiled into an overall report that can be reviewed by staff addressing population health or care management.
2. **Patient self-care/family caregivers can use the artifact as part of self-assessment or health maintenance programs.**
    a. Mr. Delta runs an overall general health self-assessment or cardiac risk self-screen as part of a self-care program. Recommendations are compiled into a list and presented immediately with the assessment results or can be delivered as a secure message to the patient on a self-care website.
3. **Data-driven screening:** The recommendations could change when relevant data change (e.g., new results for low density lipoprotein (LDL) or high density lipoprotein (HDL); new diagnosis of diabetes; new diagnosis of ASCVD).
    a. Ms. Epsilon, a patient, had a new cholesterol blood test panel performed as part of a recent visit; when the test is run, this CDS logic runs to see if any change in recommendations is called for. Ms. Epsilon's LDL has gone up to 195 milligrams/deciliter (mg/dL); her previous high was 155 mg/dL. The guideline recommends that she be placed on a statin if she has not already been taking one. The logic delivers recommendations as a message to the provider's general inbox and to the "to-do" section of the patient chart.

CDS Interventions and Suggested Actions

The Artifact Semistructured Logic section of Appendix A illustrates the CDS logic that generates the display of CDS interventions and suggested actions. At a very high level, the inclusion and exclusion logic generate the following interventions and suggested actions:

1. Recommendations for statin use in patients meeting any of the subpopulations, considering shared decision making with the patient (different messages are delivered to patients in each of the three subpopulations).
2. Notification message when insufficient data are available to process the CDS logic—in particular, if the patient has not had an LDL result in the last 3 years (to determine membership in subpopulation) or has not ever had an LDL result (to determine membership in subpopulation).
    a. The eCQM applies to all patients greater than age 21; a lipoprotein panel should be performed for all patients over that age. Many practices may not be in the habit of testing patients on the younger end of this range, which would generate many insufficient-data messages. The age range for the eCQM was carefully considered by the eCQM development group, and we have reproduced it as specified.
3. Suggested action: order a statin medication.
4. Suggested action: document any new medications being used.
5. Reference link to the eCQM specification.

6. Educational interventions: links to relevant recommendation statements, original references to the guideline, shared decision making tools, and patient education tools.
7. Exception: document why the provider and patient have decided on a management strategy differing from the recommendation.
8. Suggested exceptions could include:
    a. Patient has known adverse reactions to statins.
    b. Patient is likely to have adverse reactions to statins.
    c. Patient understood the recommendation but elects not to take a statin.
    d. Lab results are incorrect.
    e. Patient has an exclusion or exception that was not inferred by the CDS logic.

Guideline Interpretation and Clinical Decisions

Evidence Source for Artifact Development

CMS347v4 measures is a ratio of the number of patients at high risk for cardiovascular events (the denominator) who receive an order for statins or who are using statins (the numerator). The denominator is defined in three subpopulations—

1. Individuals ≥ 21 years with clinical ASCVD.
2. Individuals ≥ 21 years who have ever had a fasting or direct laboratory result of LDL ≥190 mg/dL, or who have a previous or active diagnosis of familial hypercholesterolemia, and who are not in the first subpopulation.
3. Individuals 40 to 75 years of age with type 1 or types 2 diabetes, and with a value of 70 – 189 mg/dL for the highest LDL test done in the measurement year or the 2 prior years, and who are not in the other subpopulations.[2]

Individuals who are pregnant, breastfeeding, or have a diagnosis of rhabdomyolysis are *excluded*—that is, they are not counted in the denominator or numerator when determining performance on the measure.[2]

Individuals with allergy or intolerance to statin medications, who are receiving palliative or hospice care, who have active liver disease or hepatic disease or insufficiency, who have end-stage renal disease (ESRD), or who have diabetes and a most recent LDL result <70 mg/dL are *excepted*—that is, they are counted in the denominator only if they are also included in the numerator (i.e., if they are on a statin).[2]

Additional reference information can be found in the textual metadata section of the artifact in the CDS Connect Repository.

Guideline Translation Summary

It is often necessary to interpret or adjust clinical guidelines to make them suitable for computation. Throughout the development of this artifact, the CDS Development Team engaged with eCQM subject matter experts (SMEs) to ensure that the evidence was translated appropriately and to clarify any narrative phrase in the measure that was unclear. Appendix A

(the Decision Log) provides detailed information on how the eCQM and subsequent SME clarifications informed CDS development. Some of the key interpretations and decisions include the following:

1. The eCQM specifies a "measurement period" of a year and calls for (in subpopulation 3) the determination of highest LDL during the measurement year or the 2 prior years. Because the CDS could be processed anytime during a year, this lookback time has been interpreted as 3 years prior to the processing date (current date).
2. Value sets needed to be established for computable definitions of ASCVD, ESRD, hepatic disease or failure, and pregnancy.
3. "Familial or pure hypercholesterolemia" was changed to use the codes only for familial hypercholesterolemia, based on the Cholesterol Management Work Group's determination that terms such as pure, primary, and polygenic hypercholesterolemia are often used incorrectly.
4. Intensity of statin therapy is not specified in the eCQM, although joint guidance from the ACC and the AHA guidance discusses differing levels of statins that apply to certain subpopulations. The project team followed the eCQM in simply recommending statins for appropriate patients without specifying a specific dosing level.
5. The Cholesterol Management Work Group, in interpreting "hepatic disease or failure," concluded that the best computable equivalent would be a diagnosis of cirrhosis or an active diagnosis of hepatitis A or hepatitis B or a most recent alanine transaminase (ALT) result > 150 mg/dL.
6. The ACC/AHA guideline notes that the evidence for statin use in patients over age 75 is less strong. This evidence has been turned into an additional statement on the recommendations delivered for patients in subpopulation 2.

Technical Details Regarding Artifact Implementation

This artifact is composed of several software files written in CQL. The primary focus of these software files is to allow any organization to identify patients who may benefit from statin therapy for primary or secondary prevention of CVD.

The following sections provide technical details useful for those implementing this artifact in their health IT system. After providing background information on CQL (as the programming language used to write the logic for the artifact), the document presents a listing (or manifest) of the main CQL files included in the artifact, discusses the relationships among the files, and describes the testing activities.

General Information About CQL

CQL is a data standard, governed by HL7, that is currently a Standard for Trial Use (STU).[4] CQL expresses logic in a human-readable format that is also structured enough for electronic processing of a query. It can be used within both the CDS and eCQM domains.

The following hyperlinks provide additional information on CQL:

- HL7 CQL Specification
- CQL on the Electronic Clinical Quality Information (eCQI) Resource Center
- CQL Tools (e.g., CQL-to-ELM Translator) on GitHub
- CQL Execution Engine (JavaScript) on GitHub
- CQL Evaluation Engine (Java) on GitHub

Artifact Library Manifest

The Statin Therapy eCQM artifact provides two distinct versions of the logic files—

- **Statin_Therapy_for_the_Prevention_and_Treatment_of_CVD_eCQM_Derived_FHIRv102_v1.2.0_CQL.zip**: The FHIR DSTU2-based CQL logic files were updated in April 2021 to align with version 4 of the eCQM. These files were also updated to leverage recent CQL features and compiled using the CQL 1.5.x translator.
- **Statin_Therapy_for_the_Prevention_and_Treatment_of_CVD_eCQM_Derived_FHIRv401_v1.0.0_CQL.zip**: The FHIR R4-based CQL logic files were compiled using the CQL 1.5.x translator. Although the intent of the logic remains the same as the FHIR DSTU2-based version (listed above), changes in the FHIR specification (from DSTU2 to R4) required corresponding changes to the CQL logic.

Detailed descriptions of the changes in the DSTU2 and FHIR R4 versions can be found in the **Statin_Therapy_for_the_Prevention_and_Treatment_of_CVD_eCQM_Derived_Change_Log.txt** file attached to this artifact in the CDS Connect Repository.

Each of these packages is comprised of three distinct libraries listed in **Table 1** according to their file names. Although the file names and purposes may be the same across multiple versions (e.g., FHIRHelpers), the technical content of the files varies from version to version.

Each library is represented in two formats containing the same information but formatted for different purposes. The CQL format is human-readable; the JavaScript Object Notation (JSON) format is machine-readable and is generated from the CQL using the CQL-to-ELM translator.[5]

Table 1. Artifact Manifest

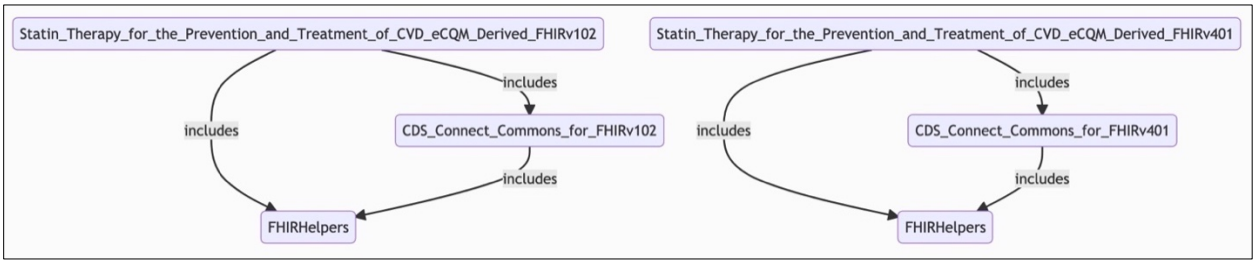
Filename	Purpose
Statin_Therapy_for_the_Prevention_and_Treatment_of_CVD_eCQM_Derived_FHIRv102.cql (FHIR DSTU2 only) or Statin_Therapy_for_the_Prevention_and_Treatment_of_CVD_eCQM_Derived_FHIRv401.cql (FHIR R4 only)	CQL representation of the Statin Therapy eCQM artifact. This file specifies the necessary logic to query relevant data, identify patients who meet the logic criteria, and return structured text that could be used in a patient-facing notification. This representation of the logic uses the HL7 standard for expressing CDS; it is considered more human-readable that other coded formats.
Statin_Therapy_for_the_Prevention_and_Treatment_of_CVD_eCQM_Derived_FHIRv102.json (FHIR DSTU2 only) or Statin_Therapy_for_the_Prevention_and_Treatment_of_CVD_eCQM_Derived_FHIRv401.json (FHIR DSTU2 only)	JSON representation of the artifact. This file specifies the necessary logic to query relevant data, identify patients who meet the logic criteria, and return structured text that could be used in a patient-facing notification. This representation of the logic is provided as an alternative to the CQL-expressed code; some IT systems may find it easier to parse the JSON version.
CDS_Connect_Commons_for_FHIRv102.cql (FHIR DSTU2 only) or CDS_Connect_Commons_for_ FHIRv401.cql (FHIR R4 only)	Common CQL functions that may be called by CDS Connect artifacts.
CDS_Connect_Commons_for_FHIRv102.json (FHIR DSTU2 only) or CDS_Connect_Commons_for_ FHIRv401.json (FHIR R4 only)	JSON representation of common CQL functions that may be called by CDS Connect artifacts.
FHIRHelpers.cql	Common CQL functions used to convert CQL data elements to FHIR and back again.
FHIRHelpers.json	JSON representation of common CQL functions used to convert CQL data elements to FHIR and back again.

Artifact Library Relationship

The project team encourages CQL developers to refactor commonly used functions into separate software files called libraries.[6] The use of libraries allows better flexibility and reusability compared to placing all CDS logic into a single, unique file for that one artifact. **Figure 1** shows the relationships between this artifact's main library file and the three supporting libraries.

When implementing this artifact, ensure that all files listed in **Table 1** in the previous section are present, and that the filenames have not been modified.

Figure 1. Artifact Relationship Diagram



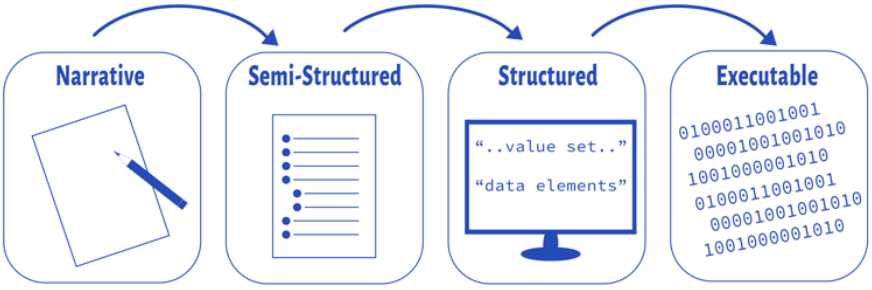
Artifact Testing

The project team tested the Statin Therapy eCQM artifact using an automated testing framework written in Node.js. This framework accepted test cases in a .csv (Comma-separated value) file, executed the artifact against each test case, and reported the success or failure of each test case. These test cases verified that basic functionality, including inclusion and exclusion criteria, worked as expected. Implementers should review their organizational priorities and develop a similar testing framework (and test cases) prior to implementation in a production system.

Implementation Checklist

Boxwala et al. developed a multilayered knowledge representation framework for structuring guideline recommendations as they are transformed into CDS artifacts.[7] The framework defines four "layers" of representation, as depicted in **Figure 2**.

Figure 2. CDS Artifact Maturity Process



1. **Narrative** text created by a guideline or clinical quality measure (CQM) developer (e.g., the recommendation statement described as a sentence).
2. **Semistructured** text that describes the recommendation logic for implementation as CDS, often created by clinical SMEs. It serves as a common understanding of the clinical intent as the artifact is translated into a fully structured format by software engineers.
3. **Structured** code that is interpretable by a computer and includes data elements, value sets, and coded logic.
4. **Executable** code that is interpretable by a CDS system at a local level. This code will vary for each site.

The CDS Connect team suggests the following "best practices" for including third-party CDS into an existing EHR system.

- Analyze the purpose, clinical statement, and use case sections of this document to ensure that your organization understands and agrees with the intended goals of the clinical guideline on which this artifact is based.
- Review the Guideline Translation Summary section of this document and Appendix A (the decision log) to ensure that your organization understands and agrees with the decisions made during the process to convert the underlying clinical guideline to a structured, computable CDS artifact.
- Technical staff should read through each of the files in the artifact manifest to understand their respective purposes and how they can be incorporated into a clinical IT system. At the time of publication, many commercial off-the-shelf health IT systems are unable to use CQL files natively; they require a separate application to convert CQL code so that it can be used in those health IT systems. Implementers should work with vendors of their respective health IT products to understand their readiness to implement CQL code and any potential adverse impacts to existing functionality. In many pilot settings, developers worked around existing health IT limitations by implementing a web service wrapper around a CQL execution engine. This is a non-trivial amount of work with two primary components.
    - A CQL execution engine with a Representational State Transfer (RESTful) Web service designed to accept requests for CQL execution and to respond with the calculated results (CQL Services[8] is one possible option for this component).
    - Modifications to the health IT system such that it will—
        - Trigger RESTful events to call the CQL execution engine.
        - Interpret the response.
        - Reflect the CQL-generated interventions and suggested actions in the health IT user interface.

- After implementers incorporate the artifact into a development environment, it should be exhaustively tested against predefined test cases. Additionally, testing should be conducted to ensure that implementation of the artifact has no adverse effect on the processing efficiency of the health IT system.
- Depending on the end user who will be interacting with the CDS (as well as the intervention action that is displayed), consider whether documentation and training material may need to be drafted and distributed. These training materials should include descriptions of modified functionality, directions for interacting with CDS rules (if different than in the current system), and contact information for assistance if functionality does not meet expectations.

Potential Reuse Scenarios

CQL code within this artifact was developed to enact a clinical guideline, but the project team anticipates that portions of the CQL code may be useful for other purposes.

- The four libraries: CDS_Connect_Commons_for_FHIRv102, CDS_Connect_Commons_for_FHIRv401, FHIRHelpers, and CDS_Connect_Conversions included in the artifact define commonly used functions in CQL files and are not specific to the Statin Use eCQM artifact. They may be used with any other CQL file that would benefit from those functions.
- Selected code blocks from the Statin Use eCQM artifact could be copied and reused in other CQL files. For example, some parties might be interested in reusing the logic in other pertinent CDS to identify female patients with an active pregnancy.

Appendix A. Decision Log

Artifact Semistructured Logic

This artifact is derived from CMS 347v4 eCQM (i.e., CMS measure ID CMS347v4, "Statin Therapy for the Prevention and Treatment of Cardiovascular Disease"). The eCQM population statements[2] are as follows.

Denominator:
All patients who meet one or more of the following criteria (considered at "high risk" for cardiovascular events, under ACC/AHA guidelines):
1) Patients aged >= 21 years at the beginning of the measurement period with clinical ASCVD diagnosis.
2) Patients aged >= 21 years at the beginning of the measurement period who have ever had a fasting or direct laboratory result of LDL-cholesterol (LDL-C) >=190 mg/dL, or were previously diagnosed with or currently have an active diagnosis of familial or pure hypercholesterolemia.
3) Patients aged 40 to 75 years at the beginning of the measurement period with type 1 or type 2 diabetes and with an LDL-C result of 70 – 189 mg/dL recorded as the highest fasting or direct laboratory test result in the measurement year or during the 2 years prior to the beginning of the measurement period.

Denominator Exclusions:
Patients who have a diagnosis of pregnancy.
Patients who are breastfeeding.
Patients who have a diagnosis of rhabdomyolysis.

Denominator Exceptions:
Patients with adverse effect, allergy, or intolerance to statin medication.
Patients receiving palliative or hospice care.
Patients with active liver disease or hepatic disease or insufficiency.
Patients with ESRD.
Patients with diabetes who have the most recent fasting or direct LDL-C laboratory test result < 70 mg/dL and are not taking statin therapy.

Numerator:
Patients who are actively using or who receive an order (prescription) for statin therapy at any point during the measurement period.

The semistructured inclusion and exclusion logic derived from the eCQM population statements is as follows.

Inclusion logic:

Patient is >= 21 years old AND one of the following:

Population 1:

History of ASCVD

Population 2:

LDL-C >= 190 mg/dL at any point in time (fasting or direct LDL-C test)

OR familial hypercholesterolemia

AND NOT ASCVD

Population 3:

Patient is >=40 and <=75 years

AND diabetes (type 1 or 2)

AND highest LDL-C < 190 mg/dL within the past 3 years (fasting or direct LDL-C test) AND MOST RECENT LDL-C >=70 mg/dL

AND NOT LDL-C >= 190 mg/dL at any point in time (fasting or direct LDL-C test)

AND NOT ASCVD OR familial hypercholesterolemia

Exclusion logic:

Pregnancy OR pregnancy observation within the past 42 weeks

OR breastfeeding OR breastfeeding observation within the past year

OR rhabdomyolysis

OR adverse effect, allergy, or intolerance to statin medications

OR hepatitis A OR hepatitis B

OR cirrhosis OR elevated ALT > 150 (> 3 times the normal limit)

OR ESRD

OR receiving palliative or hospice care

OR already receiving a statin medication

Concept Definition Decision Log

Table 2 defines many of the terms used in the semistructured CDS representation to provide clarity on what each logic concept means and why it was expressed as listed. These concepts were informed or derived from text in the recommendation statement.

The decisions and translations listed in this log were informed by the published eCQM, research review and supporting references. The CDS Development Team engaged with eCQM and Cholesterol Management SMEs to disambiguate unclear narrative phrases to ensure that the evidence was translated appropriately. This log outlines how textual phrases were translated to semistructured logic, as well as how SME and Cholesterol Management Work Group insight informed the CDS expression.

Table 2. Concept Definition Decision Log

Location in CDS Logic	Concept	Definition and/or Rationale
All populations	"at the beginning of the measurement period"	This is an eCQM term that does not directly apply to real-time CDS. CDS will evaluate the patient's age at the time of care. (Note: the eCQM logic looks for individuals who are 21 years of age before January of the current calendar year, which means that they will be 21 – 22 during the current calendar year. For subpopulation #3 in the eCQM, individuals who turned 75 years of age before January of the current calendar year would be 75 – 76 during the current calendar year. If they are 76 years old, then they fall outside the highest ACC/AHA recommendation). Evaluating age when care is provided enables the CDS to align more directly with the ACC/AHA recommendation.

Location in CDS Logic	Concept	Definition and/or Rationale
Population 1	"clinical ASCVD"	ASCVD is defined by a grouped value set that includes diagnosis and procedure concepts that reflect signs and symptoms of the disease. It is represented as a union of eight value sets published on the Value Set Authority Center to express ASCVD "conditions" (e.g., myocardial infarction, ischemic vascular disease) and procedures that imply underlying ASCVD (e.g., coronary artery bypass grafts, percutaneous coronary interventions, carotid interventions). ASCVD is expressed as an exclusion because the interventions generated by the coded logic are only relevant to *preventing* CVD. When a patient has ASCVD, different types of treatment and counseling may be indicated. Treatments and counseling for active ASCVD are outside the of scope of this artifact.
Population 2	"who have ever had"	At any point in time. This is to accommodate scenarios where LDL was elevated prior to therapy and is now lower.
Population 2	"previously diagnosed with or currently have an active diagnosis"	Specified in CQL code with HL7 clinicalStatus and verificationStatus attributes.
Population 2	"familial or pure hypercholesterol-emia"	Based on the Cholesterol Management Work Group's recommendations, this concept was changed to familial hypercholesterolemia only. The Cholesterol Management Work Group felt strongly that other classifications (i.e., pure, primary, polygenic) are misused in primary care due to poor definitions and understanding of the condition. The project team invites feedback on the use of this data element in practice.
Population 3	LDL-C result of "70-189" mg/dL	>=70 and <=189
Population 3	"as the highest…result"	In order to make populations exclusive, this is represented by 'AND highest LDL-C is <=189 mg/dL within the past 3 years.'

Location in CDS Logic	Concept	Definition and/or Rationale
Population 3	"in the measurement year or during the 2 years prior to the beginning of the measurement period"	Translated as the "last 3 years" for CDS purposes, corresponding to those 2 years prior and up to a year since the start of the measurement period.
Denominator exclusions	Exclusions	For CDS purposes, patients meeting the listed exclusions are not provided a statin recommendation; statins are contraindicated for individuals who are pregnant, breastfeeding, or have active rhabdomyolysis.
Denominator exclusions	"Pregnancy" as an Exclusion	Based on lessons learned while piloting other statin CDS artifacts in a clinical setting, pregnancy is often expressed as an observation in EHRs. Because statins are strongly contraindicated during pregnancy, an "observation" of pregnancy has been added to the exclusions (along with a diagnosis of pregnancy) to ensure patient safety.
Denominator exclusions	"Rhabdomyolysis" as an Exclusion	Based on the Cholesterol Management Work Group's recommendations, only "active" cases of rhabdomyolysis and the conditions in the designated value set should be excluded. Do not exclude "resolved" cases.
Denominator exceptions	Exceptions	For CDS purposes, patients meeting these exceptions are not targets for a statin recommendation; they would not be flagged as deficient if they did not receive a statin. In most cases, the potential benefit versus harm of initiating a statin must be closely considered for patients with the listed conditions.

Location in CDS Logic	Concept	Definition and/or Rationale
Denominator exception	"...who have the most recent fasting or direct LDL-C laboratory test result < 70 mg/dL and are not taking statin therapy"	Subpopulation 3 logic to include: AND MOST RECENT LDL-C result is >= 70 mg/dL (i.e., MOST RECENT LDL-C result is not < 70 mg/dL).
Denominator exception	"active liver disease or hepatic disease or insufficiency"	eCQM logic represents this phrase as three distinct data elements: liver disease, hepatitis A, and Hepatitis B. Based on Cholesterol Management Work Group's recommendations, this phrase is represented as cirrhosis, ALT > 150 (i.e., three times the upper normal limit), hepatitis A, and hepatitis B. Note: the ACC/AHA guidelines cites elevated ALT as a contraindication for statins, and has been used as a proxy for severe liver disease.
Denominator exception	"hepatitis A" "hepatitis B"	The Cholesterol Management Work Group had varied opinions on whether to include active/relapsed hepatitis A and B in the exclusions or express *all* liver-related conditions in one statement (i.e., cirrhosis or ALT > 150). The current representation aligns with eCQM logic (i.e., includes hepatitis A and B). Future implementers can adjust the logic to align with what would work best in their organization.

Artifact Development Decision Log

The Artifact Development Team made many decisions when translating the eCQM and developing the structured representation of this artifact. **Table 3** provides insight on those decisions, along with where the coded representation might be expanded in the future. The table lists a "Decision Category" informed by the Tso et al. journal article, titled "Automating Guidelines for Clinical Decision Support: Knowledge Engineering and Implementation," that outlines a methodology for knowledge translation.[9] It also lists the high-level "Concept" related to the entry and the "Rationale" for each decision.

Table 3. Artifact Development Decision Log

Decision Category	Concept	Rationale
Select guidelines	Age >75	The ACC/AHA guideline provides no evidence on benefit of statins for patients >75yrs. Based on the Cholesterol Management Work Group's recommendations, two decisions were made. First, if age >75 and patient has ASCVD, then add a clause to the recommendation stating that benefit has not been proven. Second, if age > 75 and patient evaluates as true for Population 2, then display the following notification: "Evaluate comorbidities, safety considerations, and priorities of care before considering a statin for patients over 75 years old."
Disambiguate	Simplification of Population 3 logic related to LDL-C level	The eCQM statement excepts patients from Subpopulation 3 when most recent LDL-C is <70 mg/dL, even if the highest LDL-C in the past 3 years was between 70 – 189. This is logically equivalent to "highest LDL-C <= 189 mg/dL in last 3 years and most recent LDL-C >=70 mg/dL."
Implementation guidance	Provide distinct messages for different populations	CQL coding will support the provision of distinct notification and rationale statements for each population. Currently, the recommendations align with eCQM specifications, which promote initiation of *any* intensity statin. Due to intellectual property constraints, the more-specific ACC/AHA guideline recommendations (http://circ.ahajournals.org/content/129/25_suppl_2/S1) are not implemented in this artifact; nevertheless, end users may adjust the notification text and the intensity of statin that is expressed in the notification prior to implementation of the artifact, if desired.

Decision Category	Concept	Rationale
Deabstract	Strength of notifications	The Cholesterol Management Work Group had varied opinions on the strength of wording to use in notifications (e.g., “start,” “discuss,” or “consider” a statin). Members underscored the importance of the discussion between patient and provider prior to initiation of a statin. Some felt that selecting a less-directive verb (e.g., “discuss” or “consider”) better represents this shared decision making.
Add explanation related to logic constraints to ensure clinical relevance	CDS vs. eCQM measurement	Original “source” content of this artifact is an eCQM, which is scored for each patient and in aggregate. The CDS representation of the eCQM provides an intervention/recommendation/action for each patient. This affects parameters such as “measurement period,” “exclusion,” and “exception” as outlined earlier. Recommendations are synthesized to encourage all eligible patients to be scored in the numerator of the eCQM.
Add explanation related to logic constraints	Evaluation of three distinct populations	Once a patient is in the target population (age >21) and is not excluded/excepted, the three populations (i.e., ASCVD, LDL-C >190, diabetic age 40 – 75 with LDL-C 70-189) will be tested in sequence. Current logic assesses each patient for each population as if the other tests had not been done; as a result, factors such as “no ASCVD” are included in tests for Populations 2 and 3 even though the patient would already have been included in Population 1 (and thus would have exited the artifact).
Deabstract to ensure clinical relevance	Clinical and Verification attributes	Specific FHIR clinical attributes (e.g., “resolved,” “active”) and verification attributes (e.g., “confirmed,” “refuted”) are designated in CQL code to express the accepted status for each condition.

Appendix B. References

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7. Boxwala AA, Rocha BH, Maviglia S, et al. A multi-layered framework for disseminating knowledge for computer-based decision support. J Am Med Inform Assoc. 2011;18 Suppl 1(Suppl 1):i132-9. doi:10.1136/amiajnl-2011-000334.

8. Agency for Healthcare Research and Quality. CQL Services GitHub page. https://github.com/AHRQ-CDS/AHRQ-CDS-Connect-CQL-SERVICES. Accessed June 4, 2019.

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