## Implementation Guide

# Statin Use for the Primary Prevention of CVD in Adults: Clinician-Facing CDS Intervention

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None of the investigators has any affiliations or financial involvement that conflicts with the material presented in this report.


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# Record of Implementation Guide Changes

| Date | Action | Notes |
|---|---|---|
| October 2017 | Published Implementation Guide | Original Implementation Guide content |
| October 2019 | Updated the Implementation Guide based on annual CDS artifact updates | Updated the *Implementation Guide's* Introduction and Background content, revised the flow of the content to enhance readability, added evidence specifications and an updated 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 CDS artifact updates | Updated content to clarify similarities/differences with Patient Facing artifact; minor wording changes to improve clarity, and expand CQL library details to account for FHIR R4 update, |
| September 2022 | Updated the Implementation Guide based on annual CDS artifact updates | The Background and Introduction were edited for clarity.<br>The content was reorganized under new headings to make navigation more intuitive.<br>Minor wording changes were made to improve clarity.<br>Updated the CQL section to reflect new CQL library names and versions. |

# Contents

# Figures



# Tables

# Background

Clinicians today face an unending stream of new research findings, new or updated clinical practice guidelines, and best practices defined by authoritative professional societies that they must incorporate into daily practice. Transforming these guidelines and best practices 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. Sharing CDS expressions enhances efficiency by removing the need for 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.

## Introduction

Beginning in 2016, the MITRE CDS Connect multidisciplinary project team has facilitated AHRQ's vision to move patient-centered outcomes research (PCOR) evidence into practice by supporting implementers, clinicians, and technology vendors in developing CDS tools that are shareable, standards-based, publicly available, and person-centered. CDS Connect has created the following resources, which are described in greater detail later in this document:

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

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

CDS artifacts are classified by a "Knowledge Level"[1] that indicates the degree to which a computer can interpret the information. The four categories of Knowledge Levels are defined as:

1. Narrative – Descriptive text created by a guideline or CQM developer.
2. Semistructured – Human-readable text that organizes in a logical sequence the recommendations for implementation in CDS.
3. Structured – Organized or patterned code that is interpretable by a computer (includes data elements, value sets, logic).
4. Executable – Code that is interpretable by a CDS system at a local level (and will vary for each particular site).

Some artifacts developed by the MITRE project team (or other teams) 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 insights outlined in the report to inform their implementation.

CDS 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 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.

The CDS Connect Repository hosts and shares CDS artifacts across a wide array of clinical topics. The Repository provides contributors with more than 40 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 to guide the creation of standards-based CDS logic using simple input 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 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 two prototype tools: one facilitates CQL testing (CQL Testing Framework); the other 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 expression. Vendors and integrators may also choose to use the CQL Testing Framework to test any site- or product-specific modifications to an 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.

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

Various audiences may find the information in this guide 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 employ this document as a resource for the process by which clinical guidelines are translated into mature CQL artifacts.

## Scope and Purpose

This document provides information about the creation and uses of the CDS logic expression (referred to as an "artifact") derived from the U.S. Preventive Services Task Force (USPSTF) full recommendation statement on Statin Use for the Primary Prevention of Cardiovascular Disease in Adults: Preventive Medication (referred to as the Statin Use: Clinician-Facing artifact in this guide), along with how it can be integrated within a health IT system. This artifact includes both the Grade B and the Grade C level recommendations. This artifact shares logic with the Statin Use: Patient-Facing artifact (also available on the CDS Connect Repository) but provides intervention text pertinent to clinicians. Text pertinent to patients is found in the

companion artifact, Statin Use for the Primary Prevention of CVD in Adults: Patient-Facing CDS Intervention, which does not include the Grade C recommendation.

The Statin Use: Clinician-Facing artifact is designed to be implemented in a clinician-facing health IT system (e.g., an electronic health record) to enable clinicians—in collaboration with patients—to decide on the use of statin medications for primary prevention of cardiovascular disease (CVD).

This implementation guide provides information about the artifact itself (i.e., the inclusion and exclusion CDS logic that generates notification text for targeted individuals). Organizations that elect to implement this code will likely choose to expand upon the CDS intervention to align with their organization's methodology and messaging, integrate with their computer provider order entry feature, and the like. The CDS logic provides the foundational structure upon which these enhanced interventions can be designed and implemented.

# Implementing and Using This Artifact

## Artifact Description

This artifact identifies adults aged 40–75 without a history of CVD who have at least one CVD risk factor (dyslipidemia, diabetes, hypertension, or smoking) and have a calculated 10-year risk of a cardiovascular event of 7.5 percent or greater. Clinicians who identify patients with that risk should consider, in consultation with the patient, using low- to moderate-dose statins for the prevention of CVD events such as heart attacks and strokes,[2] The Statin Use: Clinician-Facing artifact provides the opportunity to present information to clinicians who provide care to at-risk patients to:

- Raise awareness that the patient may have one or more risk factors for heart disease and stroke.
- Provide evidence-based reference materials.
- Encourage the clinician to talk with their patients about ways to reduce their risk including starting a statin medication as a preventive measure.

A key component of this artifact is the calculation and use of an individual's 10-year risk of developing CVD. The USPSTF recommends "using the American College of Cardiology (ACC)/American Heart Association (AHA) Pooled Cohort Equations (PCE) to calculate the 10-year risk of CVD events."[2] The ACC/AHA PCE calculates the 10-year risk of an atherosclerotic CVD (ASCVD) event and does not calculate the risk of developing atherosclerosis ("clogged arteries") in the absence of an "event" such as a heart attack or stroke.[3,4]

To align with USPSTF language and intention, this artifact evaluates 10-year ASCVD risk scores that have already been calculated using the PCE and stored within a patient record to represent a patient's "10-year risk of CVD." A structured (i.e., coded) version of the PCE entitled CMS's Million Hearts® Model Longitudinal ASCVD Risk Assessment Tool for Baseline 10-Year ASCVD Risk is publicly available on the CDS Connect Repository for healthcare organizations that do not currently have the equation available in their health IT system.[5]

## Preventive Health Scenarios Supported by This Artifact

The Statin Use: Clinician-Facing artifact was developed, piloted, and published to identify patients who are at risk for developing CVD according to logic derived from the USPSTF Statin Use for the Primary Prevention of Cardiovascular Disease in Adults: Preventive Medication recommendation statement. Once a patient who might benefit is identified, the CDS presents an alert to the clinician that prompts consideration of statin therapy for primary prevention of CVD. The artifact is intended for use by clinicians delivering care in an outpatient setting.

The artifact is designed to support the provision of preventive care in the following healthcare scenarios. (Each scenario is populated with a fictitious patient name and health data.)

1. Any time that the patient's record is opened by a clinician's direct action.
    a. Dr. Echo is going through the records of patients she will see this afternoon. When the record of Ms. Alpha, a scheduled patient, is opened in the EHR, the CDS logic provided by this artifact executes to determine whether to recommend Ms. Alpha 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. Mr. Bravo arrives for a scheduled appointment and is registered into the encounter. This registration automatically triggers the CDS logic of this artifact. Recommendations are made available as a message in the clinician's Inbox or a to-do item in the patient's record.
3. Enabling population management by identifying all patients requiring screening for CVD risk in a primary care setting.
    a. Franklin Community Care (FCC) is a midsize practice with four primary care clinicians (two physicians, a nurse practitioner, and a physician assistant) serving about 5,000 patients. FCC has noted the prevalence of several CVD risk factors in their patients, primarily hypertension, dyslipidemia, and diabetes. Therefore, they want to start a program to proactively identify those at risk of developing CVD and assist in reducing their risk. This program will also help to improve their quality metrics. The CDS inclusion and exclusion logic for this artifact is run on a monthly basis; each primary care team receives a report profiling those at risk in

their patient panel. The staff reaches out to the patients to suggest scheduling an appointment to discuss their individual risk factors and possible interventions with their primary care clinician. During the subsequent appointment, the primary care clinician provides educational information to the patient about their personal risks and discusses options for interventions to help prevent CVD, including taking a statin medication. To determine the impact of the interventions, data about the number of appointments scheduled because of the outreach, as well as specific CVD outcomes, are collected and analyzed on an ongoing basis.

## Additional Health Scenarios Supported by Customization of the Coded Expression

The coded CDS expression defines clinical concepts and criteria translated from the published USPSTF Clinical Summary: Statin Use for the Primary Prevention of CVD in Adults: Preventive Medication recommendation. Portions of the coded CDS expression can be reused to support additional scenarios that drive preventive health efforts across varied organizations, workflows, end users, and health IT systems.

Additional preventive health scenarios that could be supported by enhancing portions of this CDS logic include:

1. Enabling wellness and preventive care for employees and insured individuals through identification of specific CVD risk factors.

   Health First, a wellness provider, contracts with employers and health plans to provide a holistic package of prevention and wellness services to their employees and members. This service includes reminders when preventive health services are due, wellness education based on the individual's risk factors, and identification of resources to address those risks. Health First uses the artifact logic to identify individual participants who have one or more specific risk factors for CVD (dyslipidemia, diabetes, hypertension, or smoking) and have a calculated 10-year risk of a cardiovascular event of 7.5 percent or greater and who do not meet any of the exclusion criteria. They provide intensive wellness services to help identified participants understand the actions and activities that may help mitigate their risk. Health First monitors these activities and any individual progress over time. Each month, they provide statistical de-identified reports to the employers and health plans to reflect the effect of the interventions.

2. Providing a patient with an alert (via a health app) that they may be at increased risk for heart disease and stroke.

   a. Ms. Delta is 55 years old and has hypertension and diabetes, which are poorly controlled despite taking medications for both, in addition to high levels of low-density lipoprotein cholesterol (LDL-C). She receives a push notification from a health app about information from her healthcare team for her to review. She

opens the notification and selects the embedded link, which opens the health app and displays information indicating that she may have an increased risk for heart disease and stroke.

i. The information found in the health app provides educational topics for Ms. Delta to review regarding her risk factors and ways she could reduce her risk, including taking a statin medication to reduce her cholesterol levels. The notification also encourages her to speak with her physician about her risk and ways to reduce it. The implementing organization has developed a notification that aligns with existing organizational messages and services.

b. Mr. Echo is 52 years old with low high-density lipoprotein cholesterol (HDL-C) and high LDL-C levels (as evidenced by repeat cholesterol tests in the past 6 months). He has a diagnosis of hypertension, which he can control with medication. He smokes about one pack of cigarettes a day. His risk estimate for developing heart disease or stroke in the next 10 years is 15 percent. He receives an email indicating new information from his healthcare team is available in the patient portal for his review. He accesses the portal and discovers a message from his primary care clinician informing him that he may have an increased risk for heart disease and stroke based on his diagnosis of hypertension, high repeat cholesterol test levels, and a 10-year risk of developing CVD of 15 percent, which is above the normal range.

i. The information in the patient portal also provides educational materials for Mr. Echo to review regarding his risk factors and ways he could reduce his risk through lifestyle changes, such as healthy eating to reduce his cholesterol level. It also encourages him to speak with his physician about the possibility of starting a statin medication.

3. Modifying the CDS logic to address organizational goals and strategies.

a. Optimum Health Technologies provides CDS products to large healthcare organizations for use in their health IT. Their customer, a large hospital system, has requested CDS to identify those at risk for developing CVD who also have a history of other comorbid conditions (e.g., obesity or chronic obstructive pulmonary disease) to provide the appropriate primary care clinicians with a report generated by the CDS. The technology company uses the logic in this artifact, expanding its structured representation of the comorbid conditions to develop the requested CDS. The report is used to reach out to the identified patient population.

## CDS Interventions and Suggested Actions

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

1. Inclusions: Individuals 40 to 75 years old with one or more risk factors for CVD (dyslipidemia, diabetes, hypertension, or smoking) and a 10-year CVD risk score of 7.5 percent or greater.
2. Exclusions: Patients falling outside of the age range, or with the following:
    - A history of CVD.
    - An LDL-C lab result over 190 milligrams per deciliter (mg/dL) (an LDL-C result of over 130 mg/dL indicates dyslipidemia, but a result of over 190 mg/dL places an individual outside the scope of the recommendation statement; therefore, it is listed as an exclusion).
    - A family history of hypercholesteremia.
    - Currently pregnant or breastfeeding.
    - A diagnosis of end stage renal disease (ESRD) or receiving dialysis therapy.
    - A diagnosis of cirrhosis.
    - A diagnosis of rhabdomyolysis.
    - Those currently receiving or prescribed a statin medication.

If a patient meets the inclusion criteria and does not meet the exclusion criteria, the following interventions and suggested actions will be generated and presented to the provider:

1. Recommendations for statin use in patients with a CVD event risk score >=10 percent, encouraging shared decision making between the provider and patient.
2. Recommendation to consider statin use in patients with a >= 7.5 percent to 10 percent CVD event risk score, encouraging shared decision making between the provider and patient.
3. Notification if the patient meets exclusion criteria, or only some inclusion criteria.
4. Notification if data are missing (e.g., a patient with no LDL recorded).
5. Suggested order for a statin medication.
6. Suggested documentation of any new medications being used.
7. Educational links to relevant recommendation statements, original references to the guideline, shared decision-making tools, and patient-education tools.
8. Exception: Document why the provider and patient have decided on a management strategy differing from the recommendation.
9. Suggested exceptions could include:
    a. Patient has known adverse reactions to statins.
    b. Patient is likely to have adverse reactions to statins.
    c. Patient has understood the recommendation but elects not to take a statin.

d. Patient has a terminal condition, and the risks of preventive treatment outweigh benefits.

# Guideline Interpretation and Clinical Decisions

## Evidence Source for Artifact Development

This artifact is derived from the USPSTF full recommendation statement for Statin Use for the Primary Prevention of Cardiovascular Disease in Adults: Preventive Medication. The recommendation summary states that "the USPSTF recommends initiating use of low- to moderate-dose statins in adults aged 40 to 75 years without a history of CVD who have one or more CVD risk factors (dyslipidemia, diabetes, hypertension, or smoking) and a calculated 10-year CVD event risk of 10 percent or greater."[2] This recommendation is Grade "B," indicating that the USPSTF recommends this service, and there is high certainty that the net benefit of providing this counseling to patients is moderate to substantial.[6] The recommendation summary also states that "clinicians may choose to offer low- to moderate-dose statin therapy to certain adults aged 40 to 75 years with no history of CVD, one or more CVD risk factors, and a calculated 10-year CVD event risk of 7.5 percent to 10 percent."[2] This recommendation is Grade "C," indicating that the USPSTF recommends selectively offering or providing this service to individual patients based on professional judgment and patient preferences.[6]

## Guideline Translation Summary

It is often necessary to interpret or adjust clinical guidelines to make them suitable for computation. To assist with development of the Statin Use: Clinician-Facing artifact, the CDS Development Team engaged with the CDS Connect Cholesterol Management Work Group (WG), which was formed in late 2016. The Cholesterol Management WG consisted of cardiology and preventive health experts from government organizations, universities, and healthcare settings. The WG helped clarify inclusions and parameters described in the recommendation statement, as well as indicated exclusions that should be added to the logic to ensure patient safety. Appendix A (the Decision Log) provides detailed information on how the USPSTF recommendation statement and the WG clarifications informed CDS development for the Statin Use: Clinician-Facing artifact developed in 2017 and the Statin Use: Patient-Facing artifact developed in 2019. The only difference between the two "Statin Use" artifacts is the text that the CDS logic produces; the Statin Use: Clinician-Facing artifact delivers evidence-based information to a clinician with prescribing privileges during a medical encounter, whereas the Statin Use: Patient-Facing artifact delivers evidence-based information to patients outside of a medical encounter.

Some of the key interpretations and decisions include:

1. Defining exclusion criteria: Because the USPSTF recommendation does not explicitly list exclusion criteria, the MITRE CDS Development Team researched statin contraindications and collaborated with the Cholesterol Management WG to build out the exclusion logic. WG members provided guidance on translation of the recommendation statement, raised considerations to ensure patient safety, aided in the design of the CDS, and validated the semistructured representation of the CDS artifact.
    a. Diagnosis of active pregnancy, pregnancy observation, breastfeeding, and breastfeeding observation as exclusions: The 2018 AHA/ACC Guideline on the Management of Blood Cholesterol states, "Statins are listed as pregnancy category X and should not be used in women of childbearing potential unless these women are using effective contraception and are not nursing."[7]
    b. ESRD, ESRD encounter, dialysis procedure, and dependence on dialysis as exclusions: Chronic kidney disease has been associated with an increased risk of CVD.[8] However, multiple studies on patients with ESRD and those on dialysis have revealed little to no benefit of statin therapy in reducing CVD risk. The ACC states, "People with chronic kidney disease are at higher risk of side effects from lipid medications due to reduced renal excretion, polypharmacy, and multiple comorbidities" and "there does not appear to be a benefit to treating people on chronic dialysis, likely due to excessive competing risk."[8]

# Technical Details Regarding Artifact Implementation

The Statin Use: Clinician-Facing artifact is composed of several software files written in CQL. Their primary focus is to allow any organization to identify patients who qualify for the recommended statin medication by providing CQL representations of the CDS logic.

The following sections provide technical details useful for those implementing this artifact in their health IT system. First, they provide background information on CQL, the programming language used to write the logic for the artifact. This information is followed by a listing, or manifest, of the main CQL files included in the artifact. The relationships between these files are described, followed by a discussion on how the artifact has been tested.

## General Information About CQL

CQL is a data standard governed by HL7 that is currently a Standard for Trial Use (STU).[9] 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:

- Health Level Seven (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 Use: Clinician-Facing artifact provides two distinct versions of the logic files.

- **USPSTFStatinUseForPrimaryPreventionOfCVDInAdultsFHIRv102_v2.0.0_CQL.zip**: The FHIR DSTU2-based CQL logic files are exactly as they were piloted in summer 2019.
- **USPSTFStatinUseForPrimaryPreventionOfCVDInAdultsFHIRv401_v2.0.0_CQL.zip**: The FHIR R4-based CQL logic files are compiled using the CQL 1.5.x translator. This version was not piloted. While the intent of the logic remains the same as the FHIR DSTU2-based version, changes in the FHIR specification (from DSTU2 to R4) required corresponding changes to the CQL logic.

Detailed descriptions of the changes in the FHIR R4 version can be found in the **USPSTFStatinUseForPrimaryPreventionOfCVDInAdultss_Change_Log.txt** file attached to this artifact in the CDS Connect Repository.

Each of these packages is comprised of five 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 CQL format and JavaScript Object Notation (JSON) format alike. They contain the same information, but they are formatted to serve different purposes: The CQL format is human-readable; the JSON format is machine-readable and generated using the CQL-to-Expression Logical Model translator.[10]

**Table 1. Artifact Manifest**

| Filename | Purpose |
|---|---|
| USPSTFStatinUseForPrimaryPreventionOfCVDInAdultsFHIRv102.cql (FHIR DSTU2 only)<br>or<br>USPSTFStatinUseForPrimaryPreventionOfCVDInAdultsFHIRv401.cql (FHIR R4 only) | CQL representation of the Statin Use for the Primary Prevention of Cardiovascular Disease in Adults: Preventive Medicine recommendation. 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 clinician-facing notification. This representation of the logic uses the HL7 standard for expressing CDS; it is considered more readily human-readable than other coded formats. |

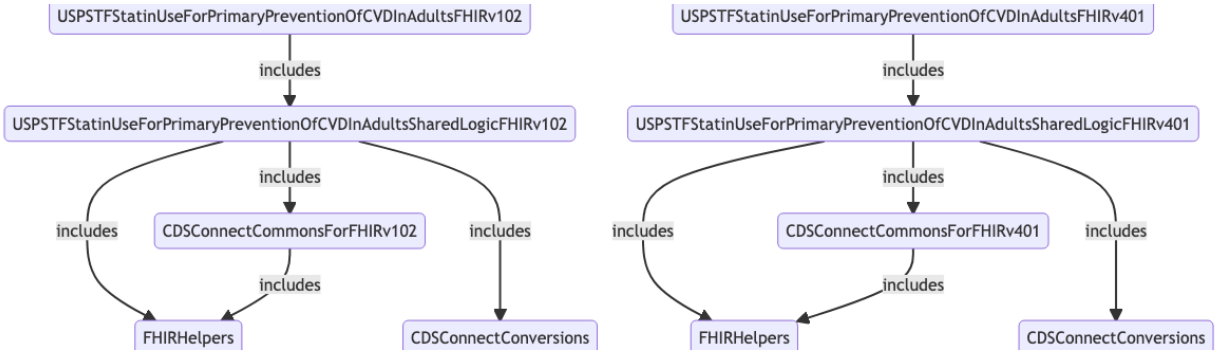
| Filename | Purpose |
|---|---|
| USPSTFStatinUseForPrimaryPreventionOfCVDInAdultsFHIRv102.json (FHIR DSTU2 only)<br>or<br>USPSTFStatinUseForPrimaryPreventionOfCVDInAdultsFHIRv401.json (FHIR R4 only) | JSON representation of the Statin Use for the Primary Prevention of Cardiovascular Disease in Adults: Preventive Medicine recommendation. 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 clinician-facing notification. This representation of the logic is provided as an alternative to the CQL-expressed code because it may be easier to parse for some IT systems. |
| CDSConnectCommonsForFHIRv102.cql (FHIR DSTU2 only)<br>or<br>CDSConnectCommonsForFHIRv401.cql (FHIR R4 only) | Common CQL functions that may be called by CDS Connect artifacts. |
| USPSTFStatinUseForPrimaryPreventionOfCVDInAdultsSharedLogicFHIRv102.cql (FHIR DSTU2 only)<br>or<br>USPSTFStatinUseForPrimaryPreventionOfCVDInAdultsSharedLogicFHIRv401.cql (FHIR R4 only) | Support library that contains CQL shared with the patient-facing version of the Statin Use: Clinician-Facing artifact. |
| USPSTFStatinUseForPrimaryPreventionOfCVDInAdultsSharedLogicFHIRv102.json (FHIR DSTU2 only)<br>or<br>USPSTFStatinUseForPrimaryPreventionOfCVDInAdultsSharedLogicFHIRv401.json (FHIR R4 only) | Support library that contains JSON shared with the patient-facing version of the Statin Use: Clinician-Facing artifact. |
| CDSConnectCommonsForFHIRv102.json (FHIR DSTU2 only)<br>or<br>CDSConnectCommonsForFHIRv401.json (FHIR R4 only) | JSON representation of common CQL functions that may be called by CDS Connect artifacts. |
| CDSConnectConversions.cql | CQL representation of a library that supports conversions from one unit to another. |
| CDSConnectConversions.json | JSON representation of a library that supports conversions from one unit to another. |
| 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 Diagram

CQL developers refactor commonly used functions into separate software files called libraries.[11] Libraries allow greater flexibility and reusability than the practice of 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 four supporting libraries.

When implementing this artifact, please 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 Statin Use: Clinician-Facing artifact was tested 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. Test cases were developed to investigate efficacy for basic expected functionality, and to test the expected inclusion and exclusion criteria.

Implementers should review their organizational priorities and develop a similar testing framework (and test cases) prior to implementation in a production system, which include the following (non-exhaustive) examples:

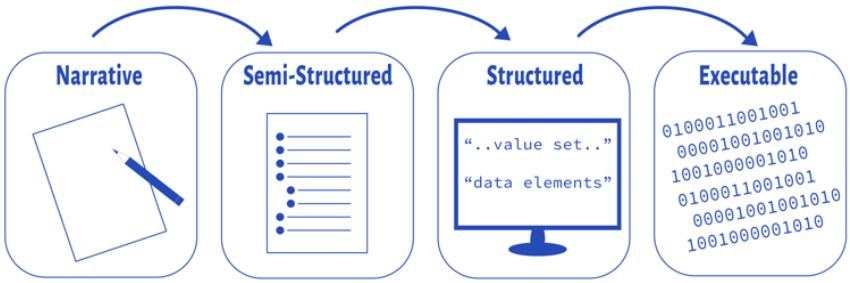
- Patient not included because their 10-year risk score is less than 7.5 percent.
- Patient excluded due to ESRD.
- Patient excluded due to a recent pregnancy diagnosis.
- Patient included because of recent LDL-C lab test result greater than 130 mg/dL.
- Patient included because they have an active diagnosis of diabetes.
- Patient included because they are a smoker.

The implementers can use the CQL Testing Framework, a publicly available CQL testing resource, to more easily develop and run test cases for validating CQL-based CDS logic.[12]

# Implementation Checklist

As noted in the Introduction, Boxwala et al. developed a multilayered knowledge representation framework for structuring guideline recommendations as they are transformed into CDS artifacts (see **Figure 2** for a summary of the process).[1] Boxwala et al. developed a multilayered knowledge representation framework for structuring guideline recommendations as they are transformed into CDS artifacts, as described in the introduction.[1] The framework defines four "layers" of representation, as depicted in **Figure 2** and described here:

**Figure 2. Artifact Maturity Process**




The CDS Connect suggests the following "best practices" for including third-party CDS into an existing health IT 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 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 capacity to implement CQL code, along with any potential adverse impacts to existing functionality. In many pilot settings, developers have 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,[13] described later in this document, is one possible option for this component).

    - Modifications to the health IT system stop:
        - 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 incorporation into a development environment, the artifact should be exhaustively tested against predefined test cases. Testing should also ensure that implementation of the artifact has no adverse effect on the processing efficiency of the health IT system.
- Depending on the end user that 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

Although the CQL code within this artifact was developed to enact a clinical guideline, portions of the CQL code will likely be useful for other purposes.

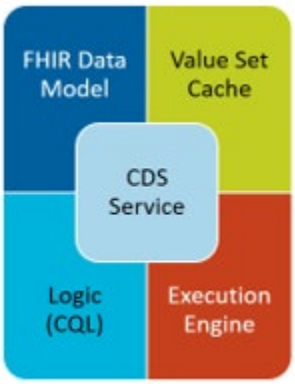
- The four libraries included the CDSConnectCommonsForFHIRv102, CDSConnectCommonsForFHIRv401, FHIRHelpers and CDSConnectConversions to define commonly used functions in CQL files; they are not specific to the Statin Use: Clinician-Facing artifact. They may be used with any other CQL file that would benefit from those functions.
- Selected code blocks from the Statin Use: Clinician-Facing artifact could be copied and reused in other CQL files. For example, some developers might be interested in reusing the logic to identify patients with an active pregnancy in other pertinent CDS.

## Integration with Health Information Technology

CQL Services was used to facilitate integration of the Statin Use: Clinician-Facing artifact into the pilot site system during the summer 2019 pilot. As depicted in **Figure 3**, CQL Services consists of four main components:

1. A data model based on FHIR Draft Standard for Trial Use 2 (DSTU2).
2. A value set service and cache for retrieving coded clinical concepts from the National Library of Medicine (NLM) Value Set Authority Center (VSAC)[14] and local storage cache.
3. Logic represented by the CQL libraries included with this artifact.
4. An execution engine.

**Figure 3. CQL Services Depiction**




When the artifact is triggered for a particular user, the necessary data are queried and aggregated on the health IT platform, then sent as a HyperText Transfer Protocol (HTTP) request to CQL Services. The original pilot in 2017 used a custom RESTful services interface, but current implementations would likely use the CDS Hooks interface.[15] CQL Services responds to the request by executing the requested artifact against the provided data, then returning the result of the CQL back to the health IT platform. The response may not contain any recommendations for the user, depending upon whether the inclusion and exclusion criteria were met. A list of the data requirements for the artifact are given in **Table 4** in Appendix B.

# Appendix A. Decision Log

## Artifact Semistructured Logic

The first sentence of the USPSTF recommendation summary reads, "adults without a history of CVD (i.e., symptomatic coronary artery disease or ischemic stroke) use a low- to moderate-dose statin for the prevention of CVD events and mortality when all of the following criteria are met: 1) they are aged 40 to 75 years, 2) they have one or more CVD risk factors (i.e., dyslipidemia, diabetes, hypertension, or smoking), and 3) they have a calculated 10-year risk of a cardiovascular event of 10 percent or greater."[2] The USPSTF recommendation summary also states, "clinicians may choose to offer low- to moderate-dose statin therapy to certain adults aged 40 to 75 years with no history of CVD, one or more CVD risk factor, and a calculated 10-year CVD event risk of 7.5 percent to 10 percent."[2]

The semistructured inclusion and exclusion logic that represents the recommendation summary, as well as additional criteria added for patient safety per the Cholesterol Management WG, is as follows:

**Inclusion logic**:

Patient is >=40 and <=75 years of age

AND one or more risk factor:

LDL-C lab result > 130 mg/dL, MOST RECENT VALUE within the past 6 years *(final, amended)*

OR HDL-C < 40 mg/dL, MOST RECENT VALUE within the past 6 years *(final, amended)*

OR diabetes (Type 1 or Type 2) *(active, relapse)*

OR hypertension *(active, relapse)*

OR smoking, MOST RECENT STATUS within the past 6 years *(final, amended)*

AND 10-year CVD risk score >= 7.5 percent, MOST RECENT VALUE within the past 6 years *(final, amended)*

**Exclusion logic**:

CVD

OR LDL-C lab result >190 mg/dL, MOST RECENT VALUE within the past 6 years *(final, amended)*

OR known familial hypercholesterolemia *(active)*

OR pregnancy *(active)*

OR pregnancy observation within the past 42 weeks *(final, amended)*

OR breastfeeding *(active)*

OR breastfeeding observation, MOST RECENT within the past 1 year *(final, amended)*

OR ESRD *(active)*

OR ESRD encounter, within the past 1 month *(in progress, finished)*

OR dialysis procedure, within the past 7 days *(in progress, completed)*

OR dependence on dialysis *(active, relapse)*

OR cirrhosis *(active, relapse)*

OR rhabdomyolysis *(active, relapse)*

OR statin medication order, within the past 2 years *(active, completed)*

OR statin medication statement, within the past 2 years *(active)*

## Concept Definition Decision Log

**Table 2** defines many 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.

USPSTF final recommendations are published on the USPSTF website, along with resources outlining their extensive investigation into concepts included in the recommendation (i.e., their research review). The decisions and translations listed in this log were informed by the published full recommendation statement, research review, and supporting references. They were also informed by previous work with the CDS Connect Cholesterol Management WG (mentioned previously), which assisted with disambiguating any unclear narrative phrase in the USPSTF recommendation to ensure that the evidence was translated appropriately. This log outlines how textual phrases were translated to semistructured logic, along with how each clinical concept and logic phrase is defined.

**Table 2. Concept Definition Decision Log**

| Location in CDS Logic | Concept | Definition and/or Rationale |
|---|---|---|
| Inclusions | “>=” | Greater than or equal to a given value (e.g., >=40 years old) |
| Inclusions | “<=” | Less than or equal to a given value (e.g., <=75 years old) |
| Inclusions | “AND one or more risk factor” | Defines a list of logic phrases where one or more of the phrases must be present in the patient record (i.e., evaluate as true) to meet inclusion criteria. The list of clinical risk factors is outlined in the recommendation statement (i.e., dyslipidemia, diabetes, hypertension, or smoking). Each of these clinical factors are defined in subsequent entries within this table. |
| Inclusions | “LDL-C lab result >130 mg/dL” | LDL-C lab result that is greater than 130 milligrams/deciliter (mg/dL). A result of >130 mg/dL is an indication of dyslipidemia, a risk factor for developing coronary artery disease (CAD) and stroke. For the purpose of the Statin Use for the Primary Prevention of Cardiovascular Disease in Adults recommendation, the USPSTF defines dyslipidemia as “an LDL-C level greater than 130mg/dL or a HDL-C level less than 40mg/dL.”[2] The FHIR Observation status must be “final,” “amended,” or “corrected” to ensure the observation is complete and verified by an authorized individual. Note: the CQL code includes an equation to convert lab results measured in “moles/volume” to “mg/dL.” |

| Location in CDS Logic | Concept | Definition and/or Rationale |
|---|---|---|
| Inclusions | "MOST RECENT VALUE" | The value closest to the date of the CDS trigger; this ensures that the logic is evaluating data that are as close to the patient's current health status as possible. |
| Inclusions | "Within the past 6 years" | The ACC/AHA recommends assessment of ASCVD risk every 4–6 years. Results older than 6 years may not reflect the patient's current condition as accurately as a result within the time span. Because lipid profile results and smoking status are inputs to ASCVD risk assessment, the CDS Connect CDS Development Team and the Cholesterol Management WG determined that a 6-year lookback supports a calculation that will most accurately reflect an individual's risk. |
| Inclusions | "HDL-C lab result < 40 mg/dL" | HDL-C lab result that is less than 40 mg/dL. A result of <40 mg/dL is an indication of dyslipidemia, a risk factor for developing CAD and stroke. For the purpose of the Statin Use for the Primary Prevention of Cardiovascular Disease in Adults recommendation, the USPSTF defines dyslipidemia as "an LDL-C level greater than 130mg/dL or a HDL-C level less than 40mg/dL."[2] The FHIR Observation status must be "final," "amended," or "corrected" to ensure the observation is complete and verified by an authorized individual. Note: the CQL code includes an equation to convert lab results measured in "moles/volume" to "mg/dL." |
| Inclusions | "Diabetes (Type 1 or Type 2)" | Diagnosis of diabetes mellitus (Type 1 or Type 2). High blood glucose levels for an extended time can damage blood vessels, leading to retinopathy and nephropathy, peripheral vascular disease, stroke, coronary artery disease, and systolic and diastolic heart failure.[16] The Clinical Status must be "active," "relapse," or "recurrence" to ensure that the condition is relevant to the patient's current health status. |
| Inclusions | "Hypertension" | Defined as essential (primary) and nonessential (secondary) hypertension conditions. The excess strain and resulting damage from hypertension causes the coronary arteries to slowly become narrowed from a buildup of plaque, leading to CVD.[17] Hypertension is the strongest risk factor for developing CVD.[18] The clinicalStatus must be "active," "relapse," or "recurrence" because this can be a transient diagnosis. |

| Location in CDS Logic | Concept | Definition and/or Rationale |
|---|---|---|
| Inclusions | "Smoking" | Defined as a cigarette or tobacco smoker. Chemicals in cigarette smoke damage the lining of the blood vessels, leading to atherosclerosis and CVD. The risk of CVD increases with the number of cigarettes smoked per day and years of smoking history.[19] The FHIR Observation status must be "final," "amended," or "corrected" to ensure the observation is complete and verified by an authorized individual. |
| Inclusions | "10-year CVD risk score >= 7.5 percent | A greater than or equal to 7.5 percent risk of an individual having a heart attack or stroke within the next 10 years. CVD risk is calculated using the ACC/AHA pooled cohort equation. The FHIR Observation status must be "final," "amended," or "corrected" to ensure the observation is complete and verified by an authorized individual. This artifact does not calculate CVD risk; it looks instead for evidence of the most recent CVD risk score that has been recorded in the past 6 years. Future implementers should determine if the ACC/AHA pooled cohort equation is implemented in their health IT system. If the equation is not embedded in their health IT system, then it is available in the CDS Connect Repository as a shared resource that is publicly available here: https://cds.ahrq.gov/cdsconnect/artifact/cmss-million-heartsr-model-longitudinal-ascvd-risk-assessment-tool-baseline-10.<br><br>Please be aware that this artifact aligns with the Grade B and the Grade C recommendation in the USPSTF Statin Use for the Primary Prevention of Cardiovascular Disease in Adults recommendation statement, which specifies a 10-year CVD risk score of greater than or equal to 10 percent for the Grade B recommendation, and a 10-year CVD risk score of greater than or equal to 7.5 percent–10 percent for the Grade C recommendation.[2] Future implementers can elect whether they choose to implement one or both of the recommendation statements in their health IT system. |
| Exclusions | CVD | CVD is defined as CAD or ischemic stroke. It is represented as a union of eight value sets published on the Value Set Authority Center to express CVD "conditions" (e.g., myocardial infarction, ischemic vascular disease) and procedures that imply underlying CVD (e.g., coronary artery bypass grafts, percutaneous coronary interventions, carotid interventions). CVD is expressed as an exclusion because the interventions generated by the coded logic are only relevant to *preventing* CVD. If a patient has CVD, different types of treatment and counseling may be indicated. Treatments and counseling for active CVD are outside the of scope of this artifact. |

| Location in CDS Logic | Concept | Definition and/or Rationale |
|---|---|---|
| Exclusions | "LDL-C lab result >190 mg/dL" | LDL-C lab result that is greater than 190 mg/dL. The USPSTF recommendation states "These recommendations do not apply to adults with a LDL-C level greater than 190 mg/dL…these persons are considered to have very high cholesterol levels and may require statin use."[2] This elevated risk places an individual outside the scope of the recommendation statement; therefore, LDL-C >190 mg/dL is listed as an exclusion. The FHIR Observation status must be "final," "amended," or "corrected" to ensure the observation is complete and verified by an authorized individual. |
| Exclusions | "Known familial hyper-cholesterolemia" | Diagnosis of familial hypercholesterolemia. The USPSTF states "These recommendations do not apply to adults with … or known familial hypercholesterolemia; these persons are considered to have very high cholesterol levels and may require statin use."[2] This elevated risk places an individual outside the scope of the recommendation statement; therefore, a diagnosis of familial hypercholesterolemia is listed as an exclusion. The clinicalStatus must be "active" to ensure that the condition is relevant to the patient's current health status. |
| Exclusions | "pregnancy" | Diagnosis of pregnancy. Per the ACC/AHA, statins should not be used during pregnancy; therefore, pregnancy is listed as an exclusion.[7] A clinicalStatus of "active" must be present to ensure that the individual is currently pregnant. |
| Exclusions | "pregnancy observation within the past 42 weeks" | Pregnancy is also expressed as a FHIR "observation" in the CDS logic to identify a second way that this concept can be recorded in a health IT system. "Within the past 42 weeks" is specified as a lookback timeframe so that only a current/active pregnancy is considered. The American College of Obstetricians and Gynecologists defines "early, full, and late term pregnancy" as up to 42 weeks of gestation. Because gestation date is not often specified in a health IT system, the CDS logic evaluates the date that a pregnancy observation was recorded in the system. Reference: https://www.acog.org/Clinical-Guidance-and-Publications/Committee-Opinions/Committee-on-Obstetric-Practice/Definition-of-Term-Pregnancy?IsMobileSet=false. The FHIR Observation status must be "final," "amended," or "corrected" to ensure the observation is complete and verified by an authorized individual. |

| Location in CDS Logic | Concept | Definition and/or Rationale |
|---|---|---|
| Exclusions | “breastfeeding” | Diagnosis of breastfeeding (which includes conditions associated with lactation). Per the ACC/AHA, statins should not be used by women who are breastfeeding; therefore, breastfeeding is listed as an exclusion.[7] The clinicalStatus must be “active” to ensure that the patient is currently breastfeeding. |
| Exclusions | “breastfeeding observation within the past 42 weeks” | Breastfeeding is also expressed as a FHIR “observation” in the CDS logic to identify a second way that this concept can be recorded in a health IT system. The rationale for specifying a 42-week lookback period is outlined in the Pregnancy Observation entry. |
| Exclusions | “ESRD” | A diagnosis that reflects ESRD. Impaired renal function may influence statin safety.[4] For this reason, evidence of ESRD is listed as an exclusion. The clinicalStatus must be “active” to ensure there is sufficient diagnostic and/or clinical evidence to substantiate the diagnosis. |
| Exclusions | “ESRD Encounter” | An encounter during which ESRD care was provided to an individual. This concept is included in the logic as an alternative way to identify an ESRD diagnosis because the organization that piloted this logic had access to claims data (i.e., encounter claims). The FHIR Encounter status must be “in-progress,” “finished,” or “completed” to ensure that the encounter occurred. |
| Exclusions | “dialysis procedure within the past 7 days” | Dialysis procedure performed within the past 7 days. Evidence of a dialysis procedure is included in the logic as an alternative way of identifying ESRD. The frequency of dialysis varies between patients but occurs approximately three times a week.[20] The CDS Connect CDS Development Team, in collaboration with the Cholesterol Management WG, determined that a lookback of 7 days would allow adequate time to determine if a patient is actively undergoing dialysis. A status of “completed” is specified to ensure that all actions involved in the procedure have taken place. |
| Exclusions | “dependence on dialysis “ | Dependence on renal dialysis, peritoneal dialysis, or hemodialysis. Evidence of dependence on a dialysis procedure is included in the logic as an alternative way of identifying a diagnosis of ESRD. A clinicalStatus of “active,” “relapse,” or “recurrence” is specified to ensure the condition is relevant to the patient’s current health status. |

| Location in CDS Logic | Concept | Definition and/or Rationale |
|---|---|---|
| Exclusions | "cirrhosis" | Diagnosis consistent with cirrhosis of the liver (regardless of morphology, histology, or etiology). Impaired hepatic function may influence statin safety.[21] For this reason, evidence of cirrhosis is expressed as an exclusion criterion. A clinicalStatus of "active," "relapse," or "recurrence" must be present to ensure the condition is relevant to the patient's current health status. |
| Exclusions | "rhabdomyolysis" | Diagnosis of rhabdomyolysis (a syndrome characterized by muscle necrosis and the release of intracellular muscle contents into systemic circulation). Rhabdomyolysis is a well-documented side effect of statin therapy.[22,23]<br><br>Evidence of rhabdomyolysis presents a safety risk related to statin therapy; therefore, it is listed as an exclusion. The clinicalStatus must be "active," "relapse," or "recurrence." |
| Exclusions | "statin medication order, …statement, … dispensed… within the past 2 years" | A statin medication order (status "active" or "completed"), patient statement (status "active"), or dispensed medication (status "in-progress" or "completed") within the past 2 years. Two years was selected as a lookback to provide a reasonable length of time to identify evidence of therapy that is relevant to an individual's recent health status. This item is listed as an exclusion to ensure that a patient who is currently receiving statins (or has recently received statins) does not receive a notification to discuss statin therapy with their primary care team. |

## Artifact Development Decision Log

The CDS Development Team made many decisions while translating the USPSTF recommendation 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's "Decision Category" was 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.[24] 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 |
|---|---|---|
| Verify completeness/ Add explanation | pregnancy (and pregnancy observation), breastfeeding (and breastfeeding observation) | These concepts are listed in the exclusion logic for patient safety reasons. The USPSTF recommendation does not explicitly list exclusion criteria; therefore, the CDS Development Team researched statin contraindications and collaborated with the Cholesterol Management WG to build out the exclusion logic. The WG was comprised of primary care and cardiology SMEs. WG members provided guidance on translation of the recommendation statement, raised considerations to ensure patient safety, aided in the design of the CDS, and validated the semistructured representation of the CDS artifact.<br><br>The 2018 ACC/AHA Guideline on the Treatment of Blood Cholesterol to Reduce ASCVD Risk in Adults states "Statins are listed as pregnancy category X and should not be used in women of childbearing potential unless these women are using effective contraception and are not nursing." |
| Verify completeness/ Add explanation | ESRD, ESRD encounter, dialysis, dependence on dialysis | These concepts are listed in the exclusion logic for patient safety reasons. The USPSTF recommendation does not list explicitly list exclusion criteria; therefore, the CDS Connect CDS Development Team researched statin contraindications and collaborated with the Cholesterol Management WG to build out the exclusion logic. As mentioned previously in other decision log entries, each of these concepts represent different ways to identify evidence of ESRD within an individual's health record.<br><br>Kidney Disease: Improving Global Outcomes (KDIGO) organization (a group of nephrologists, lipid specialists, and epidemiologists that updated their clinical practice guidelines in 2013) states "in adults with dialysis-dependent chronic kidney disease, we suggest that statins or statin/ezetimibe combination not be initiated."[25] The ACC further states "People with chronic kidney disease are at higher risk of side effects from lipid medications due to reduced renal excretion, polypharmacy, and multiple comorbidities. There does not appear to be a benefit to treating people on chronic dialysis, likely due to excessive competing risk."[8] |

# Appendix B. Data Requirements

The clinical concepts specified as data elements in the CDS logic for this artifact were documented in a Data Requirements spreadsheet, along with detailed information for each data element. **Table 4** provides some of the key information from that spreadsheet, including the complete list of all data elements used as either inclusion or exclusion criteria in the artifact. The complete spreadsheet is posted with this artifact in the Technical File section of the entry on the CDS Connect Repository.

**Table 4. Data Requirements for this Artifact**

| Data Element | Inclusion (I) vs Exclusion (X) | FHIR Resource | Required Elements |
|---|---|---|---|
| Age | I | Patient | birthDate |
| 10-year CVD risk score | I | Observation | code<br>effectiveDateTime, effectivePeriod, effectiveInstant (R4 only), or issued (to determine most recent)<br>status is 'final,' 'amended,' or 'corrected' (R4 only)<br>valueQuantity with '%' units |
| Active Cirrhosis | X | Condition | code<br>verificationStatus is 'confirmed'<br>clinicalStatus is 'active,' 'relapse,' or 'recurrence' (R4 only)<br>no abatement[x]attributes are present |
| Breastfeeding (within the last year) | X | Condition | code<br>verificationStatus is 'confirmed'<br>clinicalStatus is 'active'<br>no abatement[x]attributes are present |

| Data Element | Inclusion (I) vs Exclusion (X) | FHIR Resource | Required Elements |
|---|---|---|---|
| Breastfeeding Observation | X | Observation | code<br><br>effectiveDateTime, effectivePeriod, effectiveInstant (R4 only), or issued (to determine most recent)<br><br>status is 'final,' 'amended,' or 'corrected' (R4 only)<br><br>valueCodeableConcept |
| Myocardial Infarction (MI)<br>(component of CVD) | X | Condition | code<br><br>verificationStatus is 'confirmed' |
| Ischemic Vascular Disease<br>(component of CVD) | X | Condition | code<br><br>verificationStatus is 'confirmed' |
| Coronary Artery Bypass Graft (CABG)<br>(component of CVD) | X | Procedure | code<br><br>status is 'completed'<br><br>notPerformed is absent or false (DSTU2 only) |
| Percutaneous Coronary Intervention (PCI)<br>(component of CVD) | X | Procedure | code<br><br>status is 'completed'<br><br>notPerformed is absent or false (DSTU2 only) |
| Carotid Intervention<br>(component of CVD) | X | Procedure | code<br><br>status is 'completed'<br><br>notPerformed is absent or false (DSTU2 only) |

| Data Element | Inclusion (I) vs Exclusion (X) | FHIR Resource | Required Elements |
|---|---|---|---|
| Diabetes<br>(Type 1 or Type 2) | I | Condition | code<br>verificationStatus is ‘confirmed’<br>clinicalStatus is ‘active,’ ‘relapse,’ or ‘recurrence’ (R4 only)<br>no abatement[x] attributes are present |
| Dialysis<br>(within the last week) | X | Procedure | code<br>status is ‘completed’<br>notPerformed is absent or false (DSTU2 only)<br>performedDateTime or performedPeriod |
| Dialysis<br>(Dependence on) | X | Condition | code<br>verificationStatus is ‘confirmed’<br>clinicalStatus is ‘active,’ ‘relapse,’ or ‘recurrence’ (R4 only) |
| End Stage Renal Disease | X | Condition | code<br>verificationStatus is ‘confirmed’<br>clinicalStatus is ‘active’<br>no abatement[x]attributes are present |
| End Stage Renal Disease Encounter | X | Encounter | status is ‘in-progress,’ ‘finished’ (DSTU2 only), or ‘completed’ (R4 only)<br>reason (DSTU2 only) or reasonCode (R4 only)<br>period |

| Data Element | Inclusion (I) vs Exclusion (X) | FHIR Resource | Required Elements |
|---|---|---|---|
| Familial Hypercholesterolemia | X | Condition | code<br><br>verificationStatus is ‘confirmed’<br><br>clinicalStatus is ‘active’<br><br>no abatement[x]attributes are present |
| HDL | I | Observation | code<br><br>effectiveDateTime, effectivePeriod, effectiveInstant (R4 only), or issued (to determine most recent)<br><br>status is ‘final,’ ‘amended,’ or ‘corrected’ (R4 only)<br><br>valueQuantity with ‘mg/dL’ or ‘mmol/L’ units |
| Hypertension | I | Condition | code<br><br>verificationStatus is ‘confirmed’<br><br>clinicalStatus is ‘active,’ ‘relapse,’ or ‘recurrence’ (R4 only) |
| LDL-C<br>Result > 130 mg/dl | I | Observation | code<br><br>effectiveDateTime, effectivePeriod, effectiveInstant (R4 only), or issued (to determine most recent)<br><br>status is ‘final,’ ‘amended,’ or ‘corrected’ (R4 only)<br><br>valueQuantity with ‘mg/dL’ or ‘mmol/L’ units |

| Data Element | Inclusion (I) vs Exclusion (X) | FHIR Resource | Required Elements |
|---|---|---|---|
| LDL-C<br>Result > 190 mg/dl | X | Observation | code<br><br>effectiveDateTime, effectivePeriod, effectiveInstant (R4 only), or issued (to determine most recent)<br><br>status is ‘final,’ ‘amended,’ or ‘corrected’ (R4 only)<br><br>valueQuantity with ‘mg/dL’ or ‘mmol/L’ units |
| Pregnancy | X | Condition | code<br><br>verificationStatus is ‘confirmed’<br><br>clinicalStatus is ‘active,’ ‘relapse,’ or ‘recurrence’ (R4 only)<br><br>no abatement[x] attributes are present |
| Pregnancy Observation (within the last 42 weeks) | X | Observation | code<br><br>effectiveDateTime, effectivePeriod, effectiveInstant (R4 only), or issued (to determine most recent)<br><br>status is ‘final,’ ‘amended,’ or ‘corrected’ (R4 only)<br><br>valueCodeableConcept |
| Rhabdomyolysis | X | Condition | code<br><br>verificationStatus is ‘confirmed’<br><br>clinicalStatus is ‘active’<br><br>no abatement[x]attributes are present |

| Data Element | Inclusion (I) vs Exclusion (X) | FHIR Resource | Required Elements |
|---|---|---|---|
| Smoking/<br>Current Smoker | I | Observation | code<br><br>effectiveDateTime, effectivePeriod, effectiveInstant (R4 only), or issued (to determine most recent)<br><br>status is 'final,' 'amended,' or 'corrected' (R4 only)<br><br>valueCodeableConcept |
| Statin Therapy (Order) | X | MedicationOrder (DSTU2)<br><br>MedicationRequest (R4) | medicationCodeableConcept<br><br>dateWritten (DSTU2 only) or authoredOn (R4 only)<br>(for 2-year lookback)<br><br>status is 'active' or 'completed' |
| Statin Therapy (Statement) | X | MedicationStatement | medicationCodeableConcept<br><br>effectiveDateTime or effectivePeriod (for 2-year lookback)<br><br>status is 'active' |
| Statin Therapy (Dispensed) | X | MedicationDispensed | medicationCodeableConcept<br><br>whenHandedOver or whenPrepared (for 2-year lookback)<br><br>status is 'in-progress' or 'completed' |

# Appendix C. References


1. 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:i132-139.

2. U.S. Preventitive Task Services. Bibbins-Domingo K, Grossman DC, et al. Statin Use for the Primary Prevention of Cardiovascular Disease in Adults: US Preventive Services Task Force Recommendation Statement. JAMA. 2016;316(19):1997-2007.

3. Lloyd-Jones DM, Huffman MD, Karmali KN, et al. Estimating Longitudinal Risks and Benefits From Cardiovascular Preventive Therapies Among Medicare Patients: The Million Hearts Longitudinal ASCVD Risk Assessment Tool: A Special Report From the American Heart Association and American College of Cardiology. Circulation. 2017;135(13):e793-e813.

4. National Heart Lung and Blood Institute. Know the Differences: Cardiovascular Disease, Heart Disease, Coronary Heart Disease. https://www.nhlbi.nih.gov/sites/default/files/media/docs/Fact_Sheet_Know_Diff_Design.508_pdf.pdf. Accessed March 25, 2022.

5. The MITRE Corporation. CMS's Million Hearts® Model Longitudinal ASCVD Risk Assessment Tool for Baseline 10-Year ASCVD Risk | CDS Connect. 2018; https://cds.ahrq.gov/cdsconnect/artifact/cmss-million-heartsr-model-longitudinal-ascvd-risk-assessment-tool-baseline-10.

6. U.S. Preventitive Services Task Force. Grade Definitions. 2012; https://www.uspreventiveservicestaskforce.org/Page/Name/grade-definitions. Accessed March 25, 2022.

7. Grundy SM, Stone NJ, Bailey AL, et al. 2018 AHA/ACC/AACVPR/AAPA/ABC/ACPM/ADA/AGS/APhA/ASPC/NLA/PCNA Guideline on the Management of Blood Cholesterol: A Report of the American College of Cardiology/American Heart Association Task Force on Clinical Practice Guidelines. J Am Coll Cardiol. 2019;73(24):e285-e350.

8. Kovell L. Lipid Management Guidelines for Adults with Chronic Kidney Disease. Expert Analysis 2016; https://www.acc.org/latest-in-cardiology/articles/2016/05/31/13/00/lipid-management-guidelines-for-adults-with-chronic-kidney-disease. Accessed March 25, 2022.

9. Health Level 7 (HL7). Clinical Quality Language (CQL) Release 1 STU5 (1.5). https://cql.hl7.org/. Accessed March 25, 2022.

10. Health Level 7 (HL7). CQL-to-ELM Translator Reference Implementation. https://github.com/cqframework/clinical_quality_language/blob/master/Src/java/cql-to-elm/OVERVIEW.md. Accessed March 25, 2022.

11. Health Level 7 (HL7). Author's Guide: Using Libraries to Share Logic. https://cql.hl7.org/02-authorsguide.html#using-libraries-to-share-logic. Accessed March 25, 2022.

12. Agency for Healthcare Research and Quality. CQL Testing Framework. https://github.com/AHRQ-CDS/CQL-Testing-Framework. Accessed March 25, 2022.

13. Agency for Healthcare Research and Quality. CQL Services GitHub page. https://github.com/AHRQ-CDS/AHRQ-CDS-Connect-CQL-SERVICES. Accessed March 25, 2022.

14. National Library of Medicine. Value Set Authority Center. https://vsac.nlm.nih.gov/. Accessed March 25, 2022.

15. Health Level 7 (HL7) and Boston Children's Hospital. CDS Hooks. https://cds-hooks.org/. Accessed March 25, 2022.

16. Dokken BB. The Pathophysiology of Cardiovascular Disease and Diabetes: Beyond Blood Pressure and Lipids. Diabetes Spectrum. 2008;21(3):160-165.

17. American Heart Association. How High Blood Pressure Can Lead to a Heart Attack. 2022; https://www.heart.org/en/health-topics/high-blood-pressure/health-threats-from-high-blood-pressure/how-high-blood-pressure-can-lead-to-a-heart-attack. Accessed March 25, 2022.

18. Kokubo Y. Prevention of hypertension and cardiovascular diseases: a comparison of lifestyle factors in Westerners and East Asians. Hypertension. 2014;63(4):655-660.

19. Health and Human Services, Centers for Disease Control and Prevention. Smoking and Cardiovascular Disease. www.smokefree.gov. Accessed April 1, 2022.

20. National Kidney F. KDOQI Clinical Practice Guideline for Hemodialysis Adequacy: 2015 update. Am J Kidney Dis. 2015;66(5):884-930.

21. Stone NJ, Robinson JG, Lichtenstein AH, et al. 2013 ACC/AHA guideline on the treatment of blood cholesterol to reduce atherosclerotic cardiovascular risk in adults: a report of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines. Circulation. 2014;129(25 Suppl 2):S1-45.

22. Mendes P, Robles PG, Mathur S. Statin-induced rhabdomyolysis: a comprehensive review of case reports. Physiother Can. 2014;66(2):124-132.

23. Torres PA, Helmstetter JA, Kaye AM, Kaye AD. Rhabdomyolysis: pathogenesis, diagnosis, and treatment. Ochsner J. 2015;15(1):58-69.

24. Tso GJ, Tu SW, Oshiro C, et al. Automating Guidelines for Clinical Decision Support: Knowledge Engineering and Implementation. AMIA Annu Symp Proc. 2016;2016:1189-1198.

25. Kidney Disease: Improving Global Outcomes (KDIGO) Lipid Work Group. KDIGO Clinical Practice Guideline for Lipid Management in Chronic Kidney Disease.Chapter 2: Pharmacological cholesterol-lowering treatment in adults. Kidney Int Suppl (2011). 2013;3(3):271-279.