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Bonnie FHIR User Guide

Version 6.2.4

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Record of Changes

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6.2.4	October 14th, 2022	Nicole Hunter / SemanticBits	Updates for Bonnie 6.2.4

Table of Contents

List of Figures

1. Introduction

1.1 Background

Bonnie is a software tool that allows electronic clinical quality measure (eCQM) developers to test and verify the behavior of their eCQM logic. The main goal of the Bonnie application is to reduce the number of defects in eCQMs by providing a robust and automated testing framework. The Bonnie application allows measure developers to independently load measures that they have constructed using the Measure Authoring Tool (MAT). Developers can then use the measure metadata to build a synthetic patient test deck for the measure from the clinical elements defined during the measure construction process. By using measure metadata as a basis for building synthetic patients, developers can quickly and efficiently create a test deck for a measure. The Bonnie application helps measure developers execute the measure logic against the constructed patient test deck and evaluate whether the logic aligns with the intent of the measure.

Bonnie has been designed to integrate with the nationally recognized data standards the Centers for Medicare & Medicaid Services (CMS) quality reporting programs use for expressing eCQM logic for machine-to-machine interoperability. This integration provides enormous value to the eCQM program and federal policy leaders and stakeholders. The Bonnie tool verifies that the new and evolving standards for eCQMs used in the CMS quality reporting programs are flexible and can be implemented in software.

Bonnie was also designed to provide an intuitive and easy-to-use interface based on feedback from the broader measure developer community. A key goal of the Bonnie application is to deliver a user experience that provides an efficient and intuitive method for constructing synthetic patient records for testing and validating eCQMs.

Finally, the Bonnie software is freely available via an Apache 2.0 open source license. The CMS Electronic Health Records (EHR) Incentive Program makes all or parts of the Bonnie software available for inspection, verification, and even reuse by other government programs or federal contractors.

1.2 Purpose

The purpose of this document is to describe the functionality of the Bonnie web application that allows measure developers to test and verify the behavior of their eCQM logic. This document provides Bonnie users with step-by-step instructions for testing eCQMs by building synthetic patient records.

1.3 Application Description

The Bonnie application provides the capability to import measures defined following the Fast Healthcare Interoperability Resource (FHIR) Quality Measure Implementation Guide and Clinical Quality Language (CQL). The FHIR Quality Measure Implementation Guide specification provides the metadata and the CQL libraries provide the logic for calculating an eCQM. The Bonnie application can load an eCQM containing the FHIR R4 and CQL describing

a measure and programmatically convert both into an executable format that allows calculation of the measure directly from the specification.

The CMS MAT is the primary source for eCQMs used by the Bonnie application. Measure developers use the MAT to build eCQMs and export those measures as measure bundles containing FHIR R4 and one or more CQL libraries. These measure bundles can be downloaded from the MAT and loaded into the Bonnie user interface for measure testing.

Once an eCQM has been loaded into the Bonnie application, a user can inspect the measure logic and then build synthetic test records and set expectations on how those test records will calculate against a measure. This capability to build synthetic test patient records, set expectations against those records, and calculate the measures using those patient records provides an automated and efficient testing framework for eCQMs. Through the Bonnie-supported eCQM testing framework, measure developers can more clearly understand the behavior of the measure logic and validate that the measure logic encodes their intent, as well as validate multiple iterations of measure updates against a test deck.

In addition, the development of a test deck as part of measure development provides benefits after the measures are finalized. For example, the test deck can demonstrate the intent of the measure through the patient examples in the deck. The systems in the test deck implement those measures with a means to validate their development through a base set of synthetic patient records with known expectations for calculating against the implemented measures.
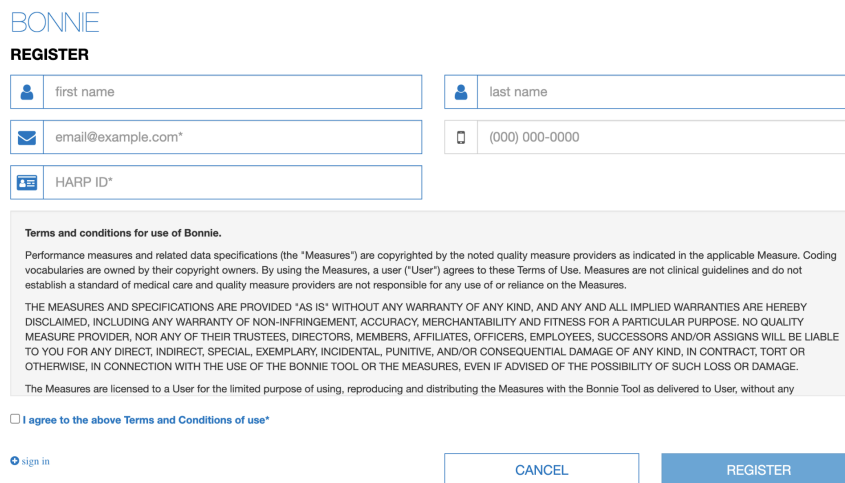
2. Accessing Bonnie and Account Management

2.1 Login Requirements

All Bonnie users are required to have a valid HCQIS Access Roles and Profiles (HARP) ID. You may already have a valid HARP account if you are able to log into the MAT. If you do not have a valid HARP account you can create one by navigating to http://harp.cms.gov and complete the registration form to create a HARP account. To create an account, users must enter their profile information, account information, and successfully complete proofing (identify verification). HARP uses a third-party service provided by Experian to verify user identities. To complete account setup, users need to log into HARP and set up two-factor authentication.

2.2 Creating a New User

Even if a user has a valid HARP ID they will still need to create a Bonnie account. A user can do this by clicking the "register" link on the Bonnie Home Page. The register link brings the user to the account creation page shown in Figure 1. A user can create a new account by filling out the fields in the registration form and clicking the "REGISTER" button. The request is then sent to the Bonnie help desk. The help desk team will then approve the request, link the HARP account to the Bonnie account, and an email will be sent to the user via the tool. At this point the user will be able to log into Bonnie.

Figure 1. Bonnie Account Registration Page

2.3 Logging In

After the user's account has been approved they will be able to log in. To log in, navigate to the Bonnie home page and select "Login". The user will be taken to the HARP login page. Users need to enter their Username and password. Then select the "Agree to our Terms & Conditions". Finally click "Sign In".
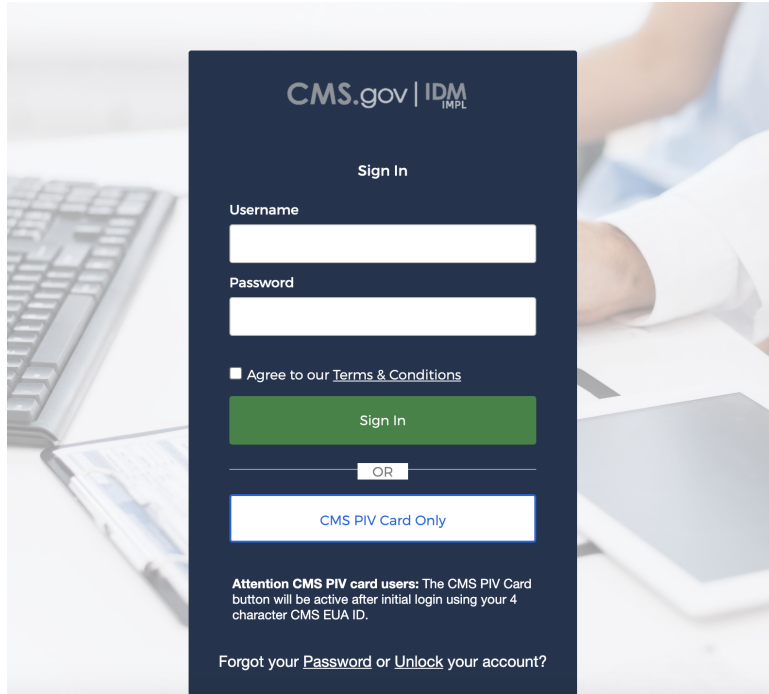
Figure 2. HARP Login Page

After clicking "Sign In" the user will be redirected to the two factor authentication page. The user can set up two factor authentication many ways. The example below is an example of Email Authentication. Okta verification, Google Authenticator, SMS Authentication, and Voice Call Authentication are other forms of two factor authentication users can set up. These can be set up, edited or changed via the user's HARP settings. Regardless of the two factor authentication selected, follow through the steps to complete the authentication. On successful two factor authentication, the user will be redirected to their Bonnie Dashboard.

Figure 3. Two Factor Authentication Example

2.4   Logging In - First Time Existing User

When a user logs into Bonnie for the first time using Bonnie 6.2.0 their existing Bonnie accounts will need to be linked with their HARP accounts.

i.2.4.1 Auto Linking Accounts

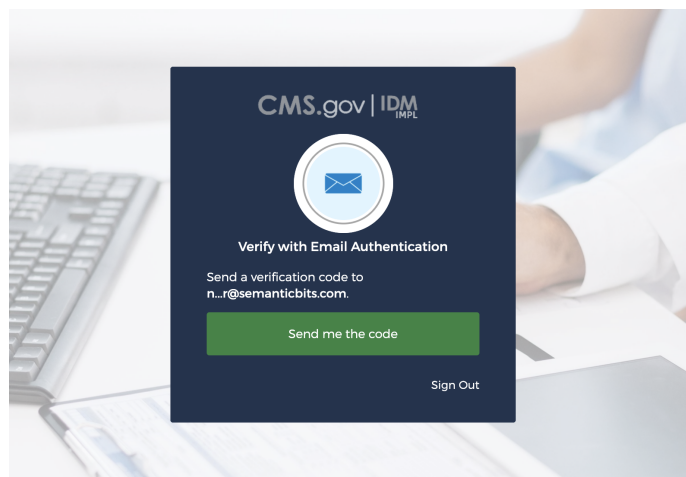Auto linking of accounts will happen if the users used the same email address to create their Bonnie account and HARP Account. The user will need to follow the login instructions (section 2.3). On redirect to the Bonnie Dashboard Bonnie will match the existing Bonnie users email automatically. A successful account link message will display.

ii.2.4.2 Manual Linking Accounts

If the user has different emails used for the HARP account and Bonnie account, no worries. When the user tries to log in no auto linking will occur. Instead the user will be redirected to the registration page. Here they can either create a new account with the email address that matches their HARP account (Section 2.2) or they can reach out to the Bonnie help desk at sb-bonnie-help@semanticbits.com. Users will need to include the email that matches their HARP account and the HARP ID and the help desk can manually link the two accounts.

2.5   Resetting a Password

Now that Bonnie utilizes HARP accounts to authenticate users please reach out to the HARP help desk or reset your password on the HARP website.

2.6   Group Accounts

Bonnie 6.2.0 has a new feature that allows the user to access Bonnie group accounts that they have access to. A group account is an account that holds measures and test cases that many Bonnie users need access to. When a user first logs into Bonnie they will arrive on their private Bonnie Dashboard. This will contain measures and test cases that only that user can access. To switch between groups the user can click on their name. This will open a drop down menu, see Figure 4, containing all the groups the user has access to. Click on the group to switch to a different group. This will load the Bonnie Dashboard screen for that specific group. When uploading a measure or updating a test patient, users need to pay specific attention to which group they are in, as that will be the only group that will see those changes.
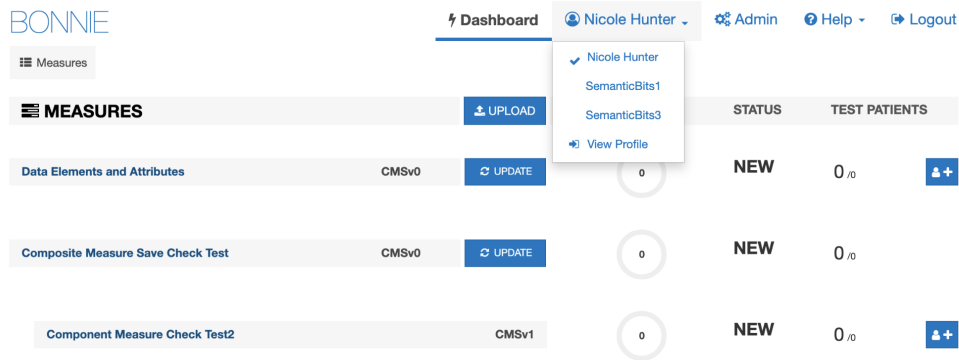
Figure 4. Group Account Drop Down

2.7 Account Management

After logging into the application, the user can view the information associated with the Bonnie account by accessing the profile page shown in Figure 5. The profile page can be opened by clicking the "View Profile" link in the group drop down shown in Figure 4. From this page, users can view the information provided to HARP during the registration process. To update this information users will need to visit their profile page on the HARP website. After the user's information is updated on the HARP website the user can log out of Bonnie and log back in and the profile page will be updated.

Figure 5. Profile Page

3.   Measure Dashboard

3.1   Overview

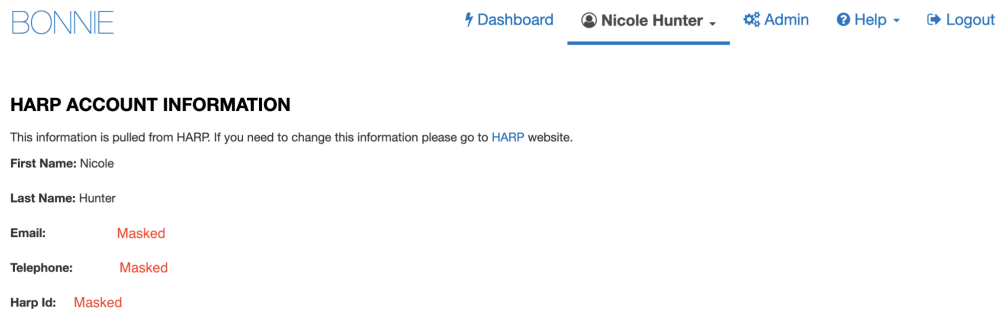The Measure Dashboard page, as shown in Figure 6, is the initial page presented to users when they log into the application. The Measure Dashboard shows the calculation status of each eCQM loaded into the system. The calculation status shows how many patient records have been built for the measure, whether the measure is currently passing or failing, and how many patients are passing or failing for each measure.
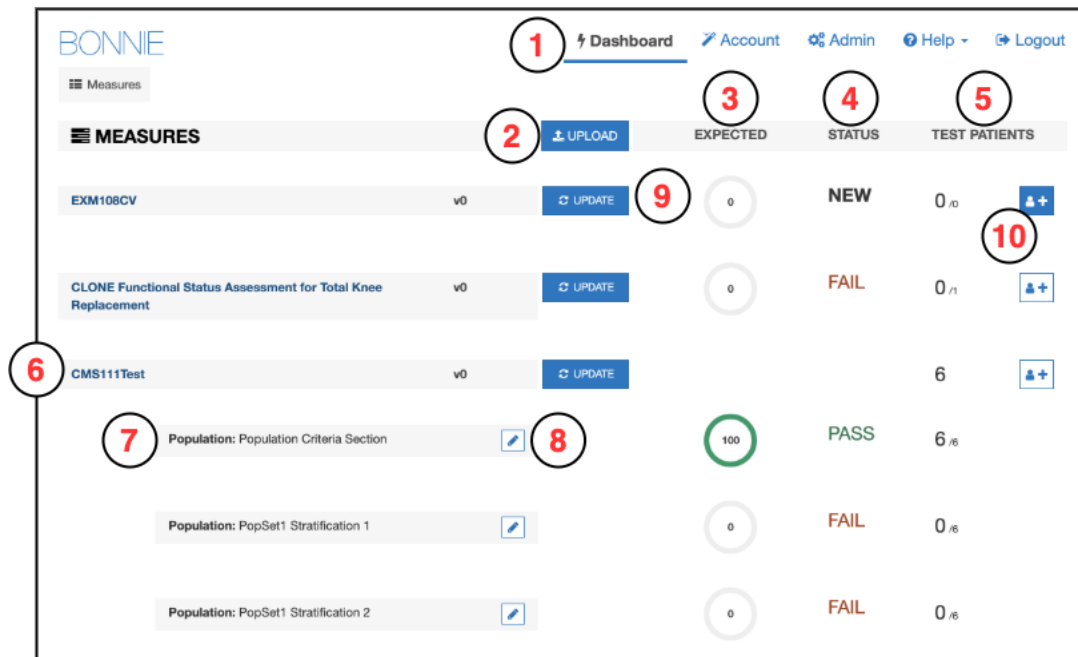
Figure 6. Measure Dashboard View

The Measure Dashboard View employs the following user interface (UI) elements (indicated by their item numbers in Figure 6):

1. Header – Allows the user to navigate to different parts of the application, access account information, send a support email (Contact), and log out of the application.

2. Upload Button – Allows the user to upload a new eCQM.

3. Expected Column – Displays the percentage of passing patients for the eCQM.

4. Status Column – Displays the status of the eCQM (New, Pass, Fail).

5. Test Patient Column – Displays the number of patients passing out of the total number of patients.

6. Measure Title – Displays the title for the eCQM and allows navigation to the Measure Dashboard View.

7. Subpopulation and stratification titles – Displays the titles for subpopulations or stratifications of an eCQM.

8. Edit Title Button – Allows the user to rename a subpopulation or stratification.

9. Update Button – Allows the user to update a previously loaded eCQM.

10. Add Patient Button – Allows the user to start building a new patient for an eCQM.

3.2 Loading a New Measure

When users log into the system for the first time, no eCQMs will be associated with the account. The user's first step is to load an eCQM into the account to begin testing the eCQM with the Bonnie application. The New Measure dialog, as shown in Figure 7, prompts the user to upload an eCQM.

The user may either upload an eCQM now or close this display and upload an eCQM later. After one or more eCQMs have been uploaded, this page displays the current set of eCQMs loaded into the system along with the subpopulations and stratifications associated with the eCQMs. The Measure Dashboard allows users to navigate to the details of individual eCQMs, upload a new eCQM, or update the definition of an existing eCQM. To upload a new eCQM, click the "Upload" button (item #2 in Figure 6) on the Measure Dashboard, which opens the New Measure Dialog shown in Figure 7.

Figure 7. New Measure Dialog

After clicking the "Upload" button, the user needs to fill out the information requested from the New Measure Dialog. These fields are outlined below and are indicated by their corresponding item numbers in Figure 7.

1. Browse – Opens a file browser enabling the user to select a MAT measure package to upload into Bonnie.

2. VSAC API Key – Field for entering the user's VSAC API key to enable Bonnie to load the value sets included within the eCQM. You can find your API key by going to https://uts.nlm.nih.gov/, signing in to your UTS account, and clicking "**My Profile.**" If you do not already have an API key, you can generate one by clicking "**Edit Profile**" then checking the box that says "**Generate new API Key**" then clicking "**Save Profile.**"

3. Value Set Options – Options to define which value sets should be downloaded from VSAC. More information about these options is included in subsection 3.2.1.

4. Type – Option to define if the eCQM is an Eligible Professional/Eligible Clinician or Eligible Hospital/Critical Access Hospital eCQM.

5. Calculation – Option to define if the eCQM is a Patient-based eCQM or an Episode of Care-based eCQM.

6. Include Supplemental Data Element Calculations – Option to define if supplemental data elements should be included in calculations and displayed in the supplemental data element section in the eCQM logic.

7. Close – Closes the New Measure Dialog without uploading the eCQM.

8. Load – Uploads the specified eCQM using the selected options.

The action of clicking the "Load" button in the New Measure Dialog uploads the eCQM to the application for processing. Once eCQM loading is complete, the application directs the user to the Measure Dashboard (Figure 6) with the new measure available.

3.2.1   Value Set Options

Bonnie allows users to download value sets associated with an eCQM based on either a VSAC profile or VSAC release. Bonnie also allows users to download draft value sets (if "Profile" is selected) and/or override their selections with value set versions specified within the CQL logic itself as shown in Figure 8.

Figure 8. Value Set Options – Profile

Figure 8 shows the Value Set Options section (item #3 in Figure 7) with the default selections. The default selections are "Profile" with the "Latest eCQM" profile selected and "Draft" checked. These default selections have the same behavior as the default selections in Bonnie v4.2. The UI elements included when "Profile" is selected are as follows:

1. Profile – When Profile is selected, Bonnie queries the Value Set Authority Center (VSAC) for value sets calculated by an expansion profile. Expansion profiles are instructions for calculating value set content based on specific code system versions and retired legacy codes.

2. Profile dropdown selector – Allows the user to select an expansion profile to use for retrieving value sets. The default selection is "Latest eCQM <<{profile}>>" where {profile} is the VSAC profile referenced by "Latest eCQM". In this screen shot, the referenced profile is "eCQM Update 2020-05-07", so the display shows "Latest eCQM <<eCQM Update 2020-05-07>>".

3. Override options with eCQM-defined versions – It is possible for an eCQM to contain value set versions within the CQL itself. This option allows the user to override the selected option to use the eCQM-defined value set versions. If this option is selected and a version for a value set is **not** defined within the measure, then Bonnie will use the selected profile to retrieve the appropriate value set version.

4. Draft – When this option is selected, Bonnie will retrieve the draft value set expansions for the selected expansion profile. Note that if the user selects draft and is not an assigned author or steward group member for one or more of the value sets included in the measure, the measure upload will fail. Draft is selected by default.

5. Information buttons – Contains additional information regarding the value set options.

Figure 9 shows the Value Set Options section (item #3 in Figure 7) with "Release" selected.

Figure 9. Value Set Options - Release

The UI elements included when "Release" is selected are as follows:

1. Release – When Release is selected, Bonnie queries VSAC for the published value sets associated with the specified release.

2. Program dropdown selector – Allows the user to select the program that includes the release they would like to use.

3. Release dropdown selector – Allows the user to select the appropriate release.

4. Override options with measure-defined versions – It is possible for an eCQM to contain value set versions within the CQL itself. This option allows the user to override the selected option to use the measure-defined value set versions. If this option is selected and a version for a value set is **not** defined within the eCQM, then Bonnie will use the selected release to retrieve the appropriate value set version.

5. Information buttons – Contains additional information regarding the value set options.

3.3   Updating an eCQM

Once the eCQM has been loaded, the testing process may identify issues with the eCQM. When issues are identified, the logic must be updated in the MAT to resolve these issues. Alternatively, the measure could be updated in the MAT as part of an Annual Update. After an eCQM has been updated in the MAT, it may be necessary to update that eCQM in Bonnie for testing. To update an eCQM, follow these steps:

1. Click the "Update" button (item #9 in Figure 6) on the Measure Dashboard, which displays the "Update Measure" dialog as shown in Figure 10.

2. Select a new MAT export zip with the updated eCQM definition.

3. Click the "Load" button to load the new version of the eCQM.

Figure 10. Updating Measure Dialog

3.4   Creating Synthetic Test Records

Once a set of eCQMs has been loaded into the Bonnie application, users can start building test patients for the eCQMs. To build a test patient from the Measure Dashboard (Figure 6), click the

"Add Patient" button (item #10). This action opens the patient builder screen as shown in Figure 18. For more information, please refer to Section 5, *Building a Patient Test Record.*

After the user creates synthetic test patients for eCQMs, the Measure Dashboard displays summary calculation results of the patients associated with each eCQM loaded by the user (Figure 6). As shown in Figure 6, UI elements numbered 3, 4, and 5 on the Measure Dashboard provide the summary results for each eCQM. In the "Expected" column (item #3), the UI displays the percentage of patients associated with the eCQM whose calculated values meet the expectations set for the patient. The "Status" column (item #4) indicates the current state of the measure—whether it is passing, failing, or new. An eCQM is in the passing state if all associated patients are meeting expectations. If one or more patients are not meeting expectations, then the eCQM is in a failing state. Any eCQM is in the new state when there are no patients associated with it. Finally, the "Test Patients" column (#5) displays the number of passing patients over the total number of patients as a fraction. The measure view, as represented in Figure 11 in Section 4, shows more detailed results for an eCQM.

4. Measure Results View

4.1 Overview

As shown in Figure 11, the Measure View page displays the detailed information, associated patients, and calculation results for a single eCQM. In this view, users can add new patients to an eCQM, update an eCQM, and delete an eCQM. To access the Measure View, click on the "Measure Title" link (item #7) on the Measure Dashboard, as shown in Figure 6.

The Measure View page presents the title and description of the eCQM, the logic for the eCQM, and a measure complexity indicator. The page lists the current set of test patients associated with the eCQM in the column on the right-hand side of the page. This column displays the summary calculation results for the patient test deck associated with the eCQM along with the list of patients and the individual calculation results for each. This page also shows the results of calculation for a single patient along with an overlay of the calculation results on the eCQM logic.

The following UI elements appear at the top of the Measure View page (indicated by their item numbers in Figure 11):

1. CMS ID – Displays the CMS ID of the eCQM.

2. Measurement Period – Displays the current Measurement Period and allows the user to update the Measurement Period.

3. Measure Actions – Allows the user to delete or update an eCQM definition.

4. Measure Subpopulations or Stratifications – Allows access to different subpopulations or stratifications in the eCQM.

5. Measure Logic – Displays a representation of the logic for the eCQM.

6. Logic Highlighted With Coverage – Displays the logic for the eCQM, highlighting which lines of the eCQM are covered by the test patients.

7. Patient Actions – Allows the user to export patient records as QRDA, Excel, and JSON.

8. Percent Successful – Displays the percent of patients currently meeting expectations for the eCQM.

9. Patients Passing Count – Displays the current number of patients meeting expectations over the total number of patients in the test deck for the eCQM.

10. Test Coverage – Displays the percentage of the measure logic that has been evaluated to true for the patient test deck. This measure provides a method for determining how much of the logic has been tested.

11. Add Patient – Allows the addition of a new patient to the test deck for this eCQM.

12. Failing Patient – Displays an example of a patient that is not currently meeting expectations for the eCQM.

13. Passing Patient – Displays an example of a patient that is meeting expectations.

14. Patient Name – Displays the name given to the patient.

15. Patient Status – Displays PASS or FAIL to indicate if the patient is meeting expectations.

16. Expand Patient Results Button – Displays the calculation details of a patient. This display will show the expected and actual values for the patient against the eCQM.

17. Show Result – If a patient has been selected with the Expand Patient Results Button, this displays the result of the logic evaluated on the selected patient.

18. Show All Results – If a patient has been selected with the Expand Patient Results Button, this displays the result of each eCQM logic block evaluated on the selected patient.

Figure 11. Measure View

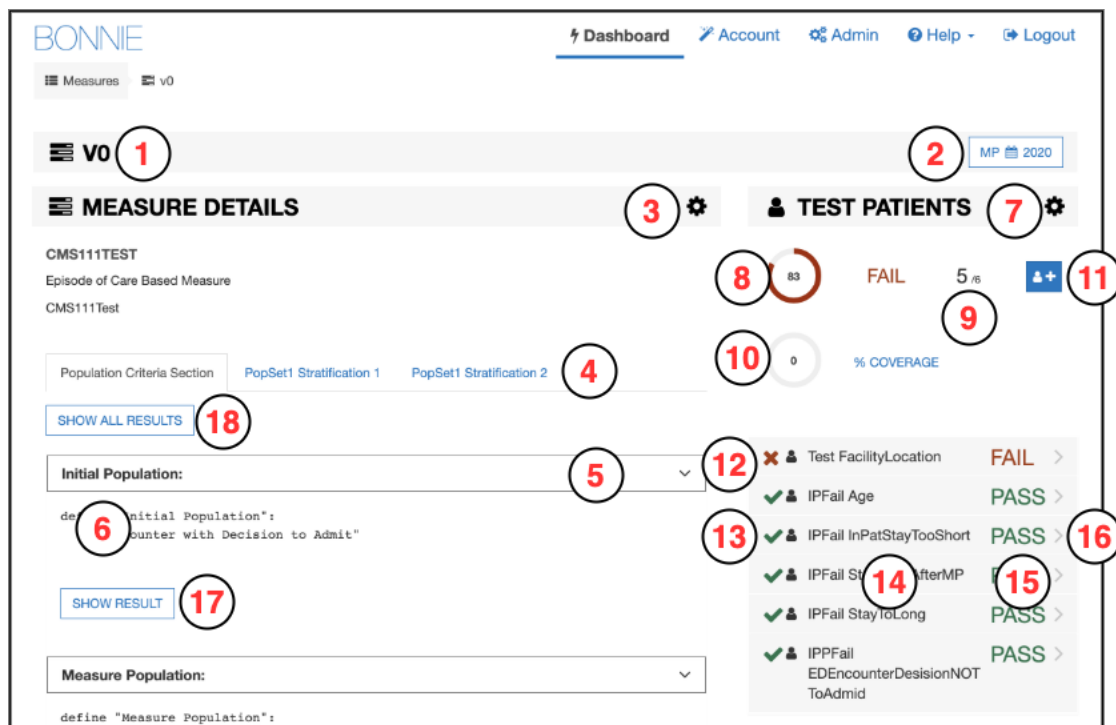The following UI elements (indicated by their item numbers in Figure 12) appear at the bottom of the Measure View Page:

1. Terminology – Displays the value sets from the eCQM and referenced libraries. Clicking on any one of these value sets will show the list of codes associated with that value set.

2. Overlapping Value Sets – Displays value sets in the eCQM and referenced libraries that have shared codes.

Figure 12. Measure Terminology and Overlapping Value Sets

4.2 Measure Logic

The left-hand side of the Measure View contains the measure title, description, and a representation of the logic. The representation of the eCQM logic is similar to the human-readable display for the eCQM provided in the MAT measure exports.

The eCQM logic section can be used to verify that the eCQM logic was properly loaded from the measure bundle without the loss of any logical conditions. The logic can also be used to evaluate the nature of the calculation of a test patient against the logic (please refer to subsection 4.4, *Calculation Results*) and to visualize the test coverage of the eCQM logic.

4.3 Creating a New Test Record

To create a new test record, begin by clicking the "Add Patient" button (item #11) in the Measure View (Figure 11). This action opens the Patient Builder (shown in Figure 18). After creating the test patient record, the application returns the user to the Measure View where the user can evaluate the results of calculating the patient against the eCQM.
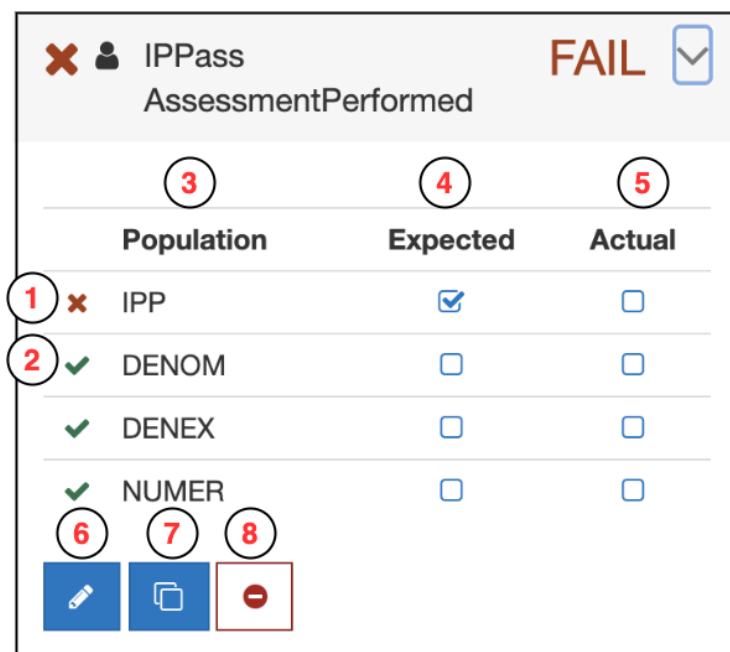
4.4　Calculation Results

The user can calculate the test patient against the logic of the eCQM in the Measure View (Figure 11). High-level results are calculated automatically when the Measure View is loaded. These high-level results appear under the test patients section on the right-hand side of the Measure View. These results include the percent of patients passing (item #8), the test coverage (item #10), individual statuses for each patient (items #12-13), and the passing patient count (item #9).

In addition to these high-level results, detailed results can be displayed for an individual patient by clicking the "Expand Patient Results" button (#16). This displays a table of expected and actual results for the patient covering each population listed in the measure and shows whether that population currently meets or fails expectations.

The Expanded Results View employs the following UI elements (as indicated by their item numbers in Figure 13):

1. Failing Population – A population for which the patient fails.
2. Passing Population – A population for which the patient passes.
3. Population Column – A list of the population types.
4. Expected Value – The user-defined expected value for the population.
5. Actual Value – The calculated value for that population.
6. Edit Patient Button – Allows editing of the selected patient.
7. Clone Patient Button – Allows cloning of the selected patient.
8. Delete Patient Button – Allows deleting of the selected patient.

Figure 13. Expanded Results View

Clicking the "Expand Patient Results" button also displays the patient results calculated against each line of logic. This information is displayed in the measure logic section of the view by highlighting each logic clause. As shown in Figure 14, Figure 15, and Figure 16, a green highlight (accompanied by a <u>solid underline</u>) indicates a passing result for the logic calculation, while a red highlight (accompanied by a <u>double-underline</u>) indicates a failing result over the applicable lines of text.
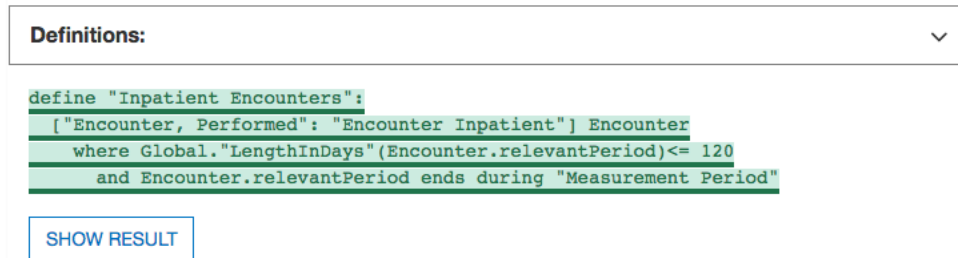
Figure 14. Logic Calculation Highlight – Passing Results

Figure 14 shows the results of a single patient calculated against the eCQM logic. The highlighting of the eCQM logic text for calculation is intended to provide a clearer understanding of why a patient is calculating to a specific population, and uses the following indications of status:

- Logic evaluated to TRUE – Green highlighting along with a solid underline
- Logic evaluated to FALSE – Red highlighting along with a double underline

The results of the calculation in Figure 14 are that the patient aligns with the logic of the initial patient population (IPP). The highlighting of the logic in Figure 14 indicates that every AND condition evaluated to true and at least one condition from each OR evaluated to true. Based on this calculation, the "Inpatient Encounters" definition evaluates to true for the patient.

The "Show Result" button at the bottom of Figure 14 can be used to expand the result, as shown in Figure 15. To collapse the results, click the "Hide Result" button.

Figure 15. Logic Calculation Highlight – Expanded Result

In Figure 15, the bottom grey box displays information regarding the result of the eCQM logic definition evaluated on the selected patient. In the example shown, the "Inpatient Encounters" definition looks for encounters in a certain time range. The grey box will display all encounters that meet that criteria; in this example, the selected patient has one encounter that meets the criteria.

In Figure 16, the population is highlighted in red, indicating that the logical statements evaluate to false. Some clauses in this figure are green, indicating they are true; however, the false female statement causes the AND logic to be false, and therefore, the results calculated in Figure 16 indicate that the patient is neither included in the IPP nor the Denominator.

Figure 16. Logic Calculation Highlight – Failing Results

4.5 Editing a Test Record

The user can edit a test patient from the Measure View (Figure 11) by clicking the "Edit" button. The user accesses the "Edit" button for a patient (item #6 in Figure 13), accessible after

expanding the patient result. Clicking the "Edit" button opens the Patient Builder (as shown in Figure 18) with the data populated for that patient. Once a patient record has been edited and saved, the application returns the user to the Measure View.

4.6   Cloning a Test Record

The user can clone a test patient from the Measure View (Figure 11) by clicking the "Clone" button (item #7 in Figure 13) to the immediate right of the "Edit" button, accessible after expanding the patient result. This action opens the Patient Builder (Figure 18) with the data populated for the patient being cloned. The difference between editing and cloning a patient is that the clone process creates a new patient based on an existing patient, while the edit process updates the data for an existing patient. Once a patient record has been cloned, edited, and saved, the application returns the user to the Measure View.

4.7   Deleting a Test Record

The user can delete a test patient from the Measure View (Figure 11) by clicking the "Delete" icon (item #8 in Figure 13) to the immediate right of the "Clone" button, accessible after expanding the patient result. Deleting a patient requires a two-step process for confirmation. Once a user deletes a patient record, the action cannot be undone. To delete a patient record, the user initially clicks the "Delete" button. A second "Delete" button is then displayed. The user must click the second "Delete" button to confirm the deletion of the patient.

4.8   Updating a Measure

The user can update a measure by clicking the "Update Measure" button, which is accessed by clicking the "Measure Actions" icon (item #3 in Figure 11). The "Update Measures" button displays the Update Measure Dialog (shown in Figure 10), which allows the user to specify a new zip package for an eCQM exported from the MAT. Once the new measure package has been entered, the user clicks the "Load" button, which updates the eCQM definition and returns the user to the Measure View with the updated measure definition.

4.9   Deleting a Measure

The user can delete an eCQM from the Measure View (Figure 11) by clicking the "Delete" icon for an eCQM. To access the "Delete" icon, the user clicks the "Measure Actions" icon (item #3 in Figure 11). A user cannot undo the deletion of an eCQM. To delete an eCQM, the user initially clicks the "Delete" icon. A second "Delete" icon is then displayed. The user must click the second "Delete" icon to confirm the deletion of the eCQM. Deleted eCQMs are no longer displayed on the Measure Dashboard.

4.10   Updating Measurement Period

The user can modify the Measurement Period associated with the Measure from the Measure View (Figure 11) by clicking the "Measurement Period" button (item #2). Once the user clicks the button, a dialog will appear (Figure 17) which allows the user to input a new Measurement

Period. Currently Bonnie does not allow you to shift all dates on the patient history by the same number of years that the measurement period will shift. This checkbox is disabled currently.

Figure 17. Change Measurement Period

– 4.11 Import FHIR Patients

Bonnie FHIR allows users to import Patients in a FHIR Patient format. To do this, navigate to the measure dashboard (Figure 11) of the measure you would like to upload FHIR patients to. Click the Patient Actions icon (Figure 11, item #7). Then select 'IMPORT' from the options. This will allow you to select a zip file created from Bonnie QDM. To see how to generate this file please see the Bonnie QDM user guide, located here. This zip file is the only file that can be imported into Bonnie. After selecting the zip file select 'SUBMIT'. This will import the FHIR patients into the measure. Users will now be able to edit those patients to add in any missing pieces. One of those missing pieces will be the expected population values. These values do not get copied over from QDM. The zip file that was uploaded contains an html file with all the pieces that could not be converted to FHIR. Use this file to help fill in any missing pieces.

*Note: By using this import patient feature you are agreeing to not upload any Protected Health Information (PHI) or Personally Identifiable Information (PII).

5.   Building a Patient Test Record

5.1   Overview

The Patient Builder view, as shown in Figure 18, allows the addition and editing of clinical data for a synthetic test patient record. The user accesses the Patient Builder view by clicking the "Add Patient" button (item #10) on the Measure Dashboard (Figure 6), or by clicking the "Add Patient," 'Edit," or "Clone" buttons from the Measure View (Figure 11).

The Patient Builder View employs the following UI elements (as indicated by their item numbers in Figure 18):

1. Patient Name – Allows the entry of a first and last name for the patient record.

2. Patient Characteristics – Allows the definition of characteristics data for the patient.

3. Measure Information – Shows the description for the patient's associated eCQM.

4. Expectations – Allows users to set the calculation expectation for each population of the eCQM.

5. Actions – Allows users to save or cancel a patient record.

Figure 18. Patient Builder View

The Patient Builder view also provides fields to either add new data or edit existing data for a patient. The patient's first and last names can be defined using the associated edit fields. Characteristics such as gender, birthdate, race, and ethnicity can be set in the characteristics

section. Fast Healthcare Interoperability Resource elements can be added to the patient history section by dragging and dropping an individual element onto the patient history section.

In addition to defining the patient data, the Patient Builder view allows the user to set expectations on the patient using the "Expectations" section. Expectations represent how the user expects the patient to calculate against the eCQM. The "Expectations" section will be different based on the type of eCQM used to build the patient record. The "Expectations" section for patient-based eCQMs provides a check box for users to select the appropriate expected populations (e.g., numerator, denominator) within which the patient will be included. The "Expectations" section for episode of care-based measures allows users to select the number of episodes of care that are expected to be included in each population using a number picker. Continuous variable measures allow users to define the expected value(s) the measure is expected to calculate for the patient.

The Patient Builder's logic section displays the logic of the eCQM against which the patient test record is constructed. As data is entered, the application continuously calculates the patient against the eCQM logic, and the results are displayed against the eCQM using the logic highlighting. Subsection 4.4 provides additional information about the descriptions of the logic highlighting technique based on calculation results shown in Figure 14 and Figure 16.

5.2   Building a Synthetic Patient

The first step in building a synthetic patient record is defining the patient name. The patient's first and last name can be set in the "Patient Name" section (item #1 in Figure 18). The user can then add patient notes and define patient characteristics in the "Patient Characteristics" section (item #2). Characteristics for the patient include data such as birthdate, race, ethnicity, gender and living status.

After defining the patient's name, the user defines the expectations for how the patient will behave and be calculated against the eCQM. The user sets the expectations for the patient in the "Expected Value" section (item #4). If the user expects the patient to align with the initial patient population logic, then the user should set that expectation here, in the "Expected Value" section (item #4). Expectations are used throughout the Bonnie application to determine if a patient is passing or failing against the eCQM.

If the expected results for the patient align with the actual results from calculating the patient against the eCQM logic, the patient passes. If the expected results do not match the actual calculated results, the patient fails. This system provides the capability to build patients and set expectations for those patients based on the intent of the eCQM. Once the eCQM is calculated, the passing state indicates that the eCQM logic aligns with the intent, while the failing state indicates that either the eCQM logic does not align with the intent or the synthetic patient was constructed improperly.

Note that in Figure 18, the depicted measure has a discrete expected value. Accordingly, the NUMER, DENOM, and DENEX options are shown. For continuous variable measures that rely on an aggregate calculation (e.g., a median time between ED arrival and ED departure), the OBSERV, MSRPOPL, and (optionally) MSRPOPLEX options are shown, as in Figure 19.

Figure 19. Continuous Variable Measures Expected Populations

Although discrete measures offer only a checkbox for including patients in the NUMER population, continuous variable measures offer the ability to set a certain percentage or minute value for a given patient calculation. This value is only available if the patient is in the MSRPOPL population.

5.3   Building the Patient History

Figure 20 depicts two events in the patient's history—an encounter and a clinical summary —based on data elements from the eCQM. When a FHIR resource is added to the patient history, it becomes an event in the patient's history. When an event is first created, any default timing elements are added and it is associated with a default code path code from each value set associated with the source FHIR resource. These defaults as well as additional data can be edited by expanding the event. Figure 20 shows an example of an expanded event from the patient history that can be edited. By clicking the expand/collapse details icon (item #3), the user can edit the details of the element.

The following UI elements are shown in Figure 20:

1. Elements Section – Contains FHIR elements that the user can add to the patient history.

2. FHIR Element – Shows a condensed summary of a FHIR element that has been added to the patient history.

3. Expand/Collapse Details – Allows hiding or expanding the details of an element.

4. Default Timing Section – This section allows the user to add default timing elements. If a timing element is a choice type (it can be different timing types) it needs to be added in the attributes section. These fields are defaulted to today's date and the measurement period year.

5. Codes Section – Allows adding the primary code path to the element. Note that Bonnie will automatically find an appropriate code and add it.

6. Attributes Section – Allows adding fields to the element (i.e., Result, Diagnoses).

7. Extension Section – Allows the user to enter FHIR extension attributes. URL is required, value is optional. Value can be many different types. First select your type then fill in the value

8. Delete Button – Allows deleting an element from the patient history.

9. CQL Calculation Results – Shows the results for each of the populations.

10. Show Result – Displays the result of the logic evaluated on the patient.

11. Show All Results – Displays the result for each eCQM logic block evaluated on the patient.

Figure 20. Building Patient History, Including Edit Clinical Element View

After the user defines the patient characteristics, the user builds a patient history from FHIR elements extracted from the eCQM. The available elements from the eCQM are organized by category and listed in the "Elements" section (item #1). The user can click a category to expand the list of available elements. Expanding this list allows the user to click and drag an individual element onto the patient history (item #2).

Several fields in the Edit Clinical Element View can be edited for an event in the patient history using the controls shown in Figure 20. These fields include the default timings of the event (items #4), codes (item #5), various attributes (item #6), and extensions (item #7). The timing elements can be set for an event by either typing into the text fields directly or by using the date/time pickers that are displayed when the field is selected. An undefined start time and end time can be set for the event (used for active or ongoing events) by selecting the "Undefined" checkbox. Selecting the "Undefined" check box clears the date/times, indicating that the event has not started/ended.

Attributes can be set for an event. Attributes such as ordinal, severity, discharge date/time, etc. can be added using the "Attributes" section. Attributes are added by selecting the type of the field (scalar, coded, or time) and entering a scalar value, selecting a value set, or entering a date.

Some Attributes are References to other FHIR elements. When adding an attribute that is type reference the attribute selection will look like Figure 21. The following UI elements will be displayed.

1. Labels – Where you can see other attributes and their values already added
2. Attribute Selector – Where you select which attribute you will add to an element
3. Attribute Type Selector – Where you will see the type of the attribute. In this instance is "Reference".
4. Reference Type Selector – Some Reference attributes allow you to reference different FHIR Resources. This selector will allow you to specify which FHIR Resource you wish to reference.
5. Value Set/Direct reference Code – Your referenced element needs to be tied to a Value Set or Direct Reference Code. This drop down contains a list of all the Value Sets and Direct reference codes that have been added to your measure. If none of these codes are what you need you are also able to select 'Custom Code'. This will allow you to specify your own Code that was not included in the measure.
6. Plus Button – This is where you will add your attribute. Clicking this button will span a new element card below your current card. Focus will be drawn to that card for you to enter all relevant information for that element.

Figure 21. Attribute Section while Adding a Reference Attribute

Finally, events can be removed from the patient history by clicking the "Delete" icon (item #10). Deletion requires a two-step process. After initially pressing the "Delete" icon, the user is prompted to depress the "Delete" icon a second time to confirm the deletion.

5.4   Incremental Calculation

The final section of the Patient Builder View is the logic section. This section displays a representation of the logic for the eCQM against which the patient is constructed. The logic can be a reference to help describe the details of the data that should be added in building the synthetic patient.

The logic section continuously displays the results of calculating the patient against the eCQM by means of the logic highlighting described in Figure 14 and Figure 16. Any modification made to a patient triggers a recalculation of the patient against the eCQM, which updates the results of the calculation displayed by the logic highlighting. Therefore, while the user constructs the patient record, the user can inspect the behavior of the logic relative to the patient.

When the user has completed constructing a synthetic patient, the user clicks the "Save" button in the Patient Builder View. This action adds the patient to the test deck for the measure and returns the user to the Measure View. After the user creates the first patient, additional patients can be created from scratch or cloned from existing patients to extend the coverage of the test deck against the eCQM.

6. Feedback and Support

An issue tracker and feedback email list are available to support the resolution of issues and to answer questions related to the Bonnie application. The Bonnie issue tracker is available on the ONC Jira system at: http://jira.oncprojectracking.org/browse/BONNIE

When users encounter bugs in the Bonnie application, they should use the issue tracker to report bugs, ask questions, or to request new features. To add an issue, users must create a login account in the Jira system. Once an issue has been entered, the Bonnie team will review and prioritize it.

7.   Frequently Asked Questions

Does Bonnie replace Cypress[1] or is it an alternative to Cypress for certification?

No. Bonnie is a testing tool for measure developers to test eCQMs as they are being authored, while Cypress is the CMS quality reporting program certification tool. Bonnie cannot be used for CMS quality reporting program certification for vendors.

Bonnie provides insight into the details of how eCQM logic behaves. This makes it useful to vendors, measure developers, and others in the eCQM space who would like to better understand the behavior of eCQMs. The Bonnie testing tool uses the same measure calculation engine as the Cypress tool. Therefore, Bonnie can be used to better understand the behavior of the eCQMs when implementing an eCQM prior to certification.

Can I export patient records from Bonnie?

Yes! Bonnie FHIR allows for patient records to be exported in a JSON format. Users can export patients by clicking on the "Patient Action" Icon on the Measure Results View Page. Both a JSON file containing all patients as well as individual JSON files containing each individual patient will be presented to the user. See Section 4.1 for further details.

Can I load patient records into Bonnie?

Currently, Bonnie does not support loading patient records into the tool. If you would like to calculate eCQMs using existing patients, the popHealth tool may be a better solution.

Does Bonnie automatically generate patient records?

Currently, Bonnie does not offer the capability to automatically generate patient records based on the eCQM logic. The goal of Bonnie is to allow the construction of carefully considered patient scenarios. These synthetic patient records are intended to have an expected result based on the intent of the eCQM. Automatically generating patient records would generate patients that align with the eCQM logic as written, but if there were issues in the eCQM logic, these patients might not align with the intent of the eCQM.

My patient does not match the logic of the Initial Population. Why is the patient passing?

A test in Bonnie is based on assigning an expected outcome to a synthetic patient record based on the intent of the eCQM. A patient can be constructed with the expectation that the patient calculated is to be included in the Initial Patient Population. If the patient actually calculates to the Initial Patient Population, then the test passes. If the patient does not calculate to the Initial Patient Population, then the test fails.

There must be an exact match between the patient's alignment and the expectation's needs. For instance, if the expectation is set for only the Initial Patient Population, and the patient calculates to the Initial Patient Population and the Denominator, the test fails. Similarly, a patient can be constructed with the expectation that the patient does not align with any of the eCQM populations. In this case, if the patient does not calculate into the Initial Patient Population, the

test will pass. If a patient is constructed with the expectation set of not aligning with any of the eCQM populations and that patient calculates into the Initial Patient Population, that test will fail.

Where can I get help with Bonnie?

The Bonnie application has a Help menu in the header. Once you log into the application, you can use the help menu to send an email to the Bonnie feedback list to (a) access the Bonnie issue tracker to enter a bug, ask a question, or request a feature; and (b) access the user guide that provides step-by-step instructions on using the Bonnie tool.

What measure formats can I load into the Bonnie tool?

The Bonnie application can load CQL 1.4 measure packages from the Measure Authoring Tool using the FHIR R4 model. Note that when loading, you will need a National Library of Medicine (NLM) Value Set Authority Center (VSAC) account (https://uts.nlm.nih.gov/license.html) to download the value sets associated with the measure.

Do I have to be a measure developer to use the Bonnie tool?

No. Anyone can sign up for a Bonnie account using the "register" link on the login page.

Do I need to be a Measure Authoring Tool user to use the Bonnie tool?

Normally, no, but Bonnie requires you import a Measure Authoring Tool (MAT) bundle to be successful. Since no FHIR measures bundles have been posted to the CMS website yet you will need to be a current MAT user or receive an export from a current MAT on FHIR user.

Can Bonnie be used to calculate the results for a large number of patient records?

Bonnie is not designed to handle calculations for more than a few hundred patient records per measure. If you are interested in calculating eCQMs against a larger number of patient records, the popHealth tool may be a better solution.

What character set should I avoid in my test patient names so that it will work well with QRDA?

Bonnie test patients allow many characters for their names, however, certain characters should not be used as they could cause errors in Bonnie or the QRDA export.. We recommend you do NOT use the following characters:

(pound), % (percent), & (ampersand), { (left curly bracket), } (right curly bracket), \ (black slash), < (left angle bracket), > (right angle bracket), ? (question mark), / (forward slash), (blank spaces), $ (dollar sign), ! (exclamation point), ' (single quotes), " (double quotes), : (colon), @ (at sign), + (plus sign), ` (backtick), | (pipe), = (equal sign), (horizontal tab), , (comma)

What FHIR attributes does Bonnie FHIR currently support? Where can I see the attributes that others users have requested to be supported in Bonnie FHIR?

Bonnie currently supports certain attributes in the QI-CORE profile. The Bonnie team is diligently working to add more attribute support. You can find the list of currently supported attributes here. Attributes highlighted in <mark>yellow</mark> are attributes that have been requested and attributes highlighted in <mark>green</mark> are attributes that will be added in the next Bonnie release.

What version of the CQL Execution Engine Does Bonnie use?

Bonnie currently uses CQL Execution Engine version 2.3.3. Updates and what is included in this version can be found here.

Acronyms

Acronym	Definition
CMS	Centers for Medicare & Medicaid Services
CQL	Clinical Quality Language
CQM	Clinical Quality Measure
eCQM	Electronic Clinical Quality Measure
ED	Emergency Department
EH	Eligible Hospital
EP	Eligible Professional
FHIR	Fast Healthcare Interoperability Resources
HHS	Department of Health and Human Services
HTML	Hypertext Markup Language
IPP	Initial Payment Population
MAT	Measure Authoring Tool
NLM	National Library of Medicine
ONC	Office of National Coordinator for Health Information Technology
QRDA	Quality Reporting Document Architecture
UI	User Interface
UMLS	Unified Medical Language System
VSAC	Value Set Authority Center
XML	Extensible Markup Language