

## Step-by-Step Guide to MAV-clic: Framework for the Health Care Data Analysis

## Supplementary Material: “MA V-clic: Management, Analysis and Visualization of Clinical Data”

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## Step-by-Step Guide to MAV-clic: Framework for the Health Care Data Analysis

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### Abstract

Healthcare data includes information about patient life style, medical history, visits to the practice, lab tests, imaging test, diagnoses, medications, surgical procedures, genomics profile, consulted providers and claims. Adequate and analytic access to the health care data has potential to revolutionize the field of medicine by improving the quality and transition of care, and developing better understanding of biological mechanisms and modelling complex biological interactions by integrating and analyzing knowledge in a holistic manner. To fulfill the growing interests in implementing the health information system, MAV-clic is developed to satisfy the requirements of data owners as well as data users in the healthcare system. As the multi-database management system, it can benefit for the data owners to manage huge database from multiple sources in a centralized manner. The data having different contents, formats, styles, sizes, structures can be extracted and transformed into the normalized format and stored into the MAV-clic system with High performance computing technology. The well-organized data management features allow for data users to analyze the complex, disparate healthcare data. Analytics process in MAV-clic can help building the cohort in terms of demographic information, and time information as well as generating evidence using analytics of the patient's information along with diagnoses, medications, laboratory results. MAV-clic also offers the customized functions, which can explore the quality measures of the hospital using the EHR database, visualize the patterns of the analyzed results, and report the summary in an automated and timely manner. In this manuscript we describe the potential of MAV-clic by explaining its features for clinical, users, measures and database of database management, analysis, visualization, sharing and reporting.

### Keywords:

Analysis, Database, Data Mining, HIPAA, Patient Generated Health Data

## MAV-clic

Trying achieving the goals for the provision of better care and better health of population at lower costs together with better work-life for clinicians and staff at UConn Health, in this manuscript we present MAV-clic (Management, Analysis and Visualization of Clinical Big Data).

MAV-clic is supported by the SNE-PTN (Southern New England Practice Transformation Network), one of 29 networks across the country, selected by Centers for Medicare and Medicaid Services (CMS), as part of the Transforming Clinical Practices Initiative. The audience of SNE-PTN and MAV-clic is not limited to doctors from all specialties, Podiatrists, Optometric, Oral Surgeons, Dentists, Chiropractors, Physician Assistants, Nurse Practitioners, Clinical Nurse Specialists, Clinical Social Workers, Clinical Phycologists, Registered Dietitians, Nutrition Professionals Physical Therapists, Occupational Therapists and Qualified Speech-Language Therapists. As, aims include use of health care data to improve quality and transition of care, obtain actionable care gap based information about patients and develop communication and coordination across:

- Hospitals,
- Specialists,
- Behavioral health,
- Oral health,
- Community based providers
- Sub-acute care,
- Nurse,
- Quality Inspectors,
- Management,
- Researchers,
- Analysts.

MAC-clic is a new HIPAA compliant framework for the health care data analysis at the UConn Health, CT, USA. It implements health care and user's data security, which includes:

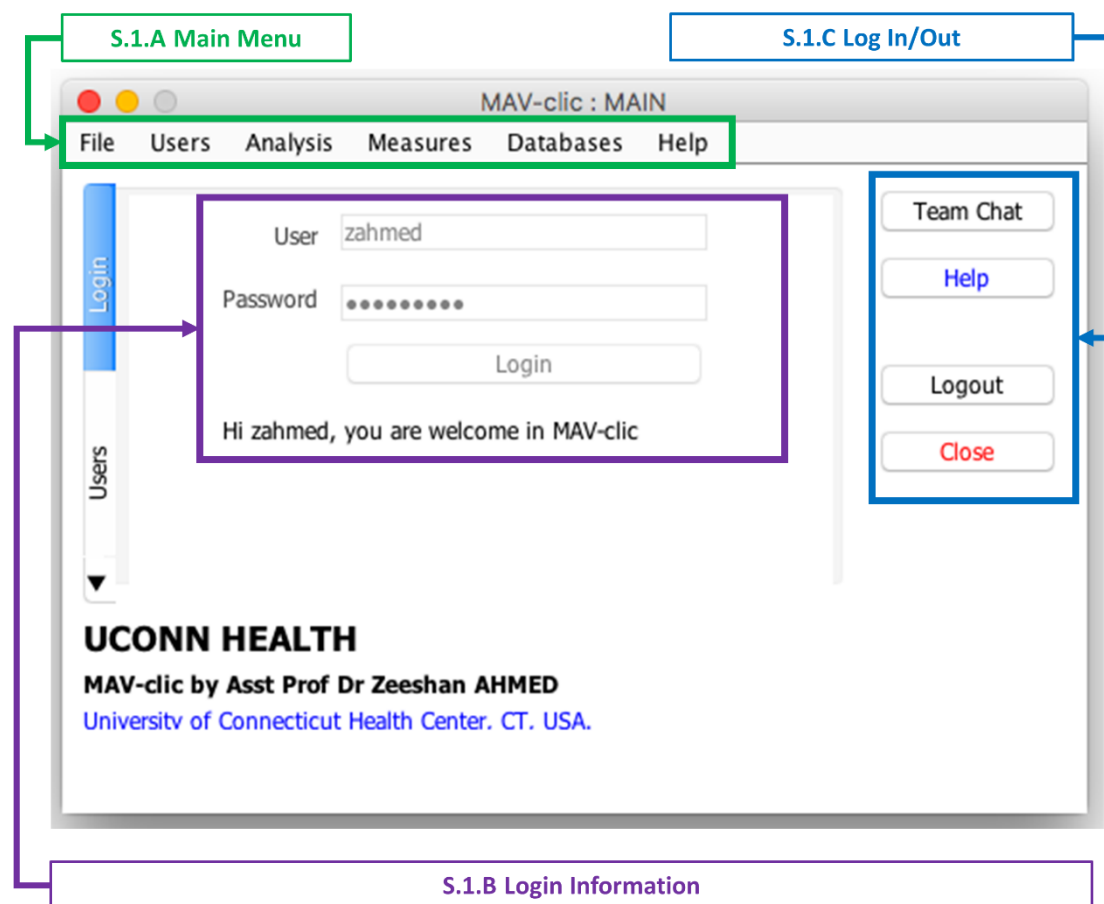
- 1) Application and Data Criticality,
- 2) Risk Management and Analysis,
- 3) Information System Activity Review,
- 4) Contingency Plan,
- 5) Device and Media Controls,
- 6) Access Controls.

MAV-clic is a new large scaled, user-friendly, interactive, cross-platform, encrypted, multi-roles based, automated, customized and centralized multi-database management framework for health care data management, analysis and visualization. It is based on Butterfly model and product line architecture; therefore all major modules are capable of performing individual key roles as well as integrating each other. It is developed using JAVA programming language and tested at Microsoft Windows 10 and macOS Sierra (Version 10.12.6) operation systems.

The graphical user interface of MAV-clic is divided in to following six modules: Main, Users, Analysis, Measures, Databases and ETL (Extract, Transform and Load). In this manuscript, we guide users in learning about MAV-clic by describing all the features of these all modules.

## MAV-clic Main

MAV-clic Main is the primary graphical user interface of the MAV-clic. Main offers six tabs (Login, Users, Analysis, Measures, Database and ETL) can be observed in the left panel and each tab makes its own role in terms of management, analysis and visualization of the clinical data stored in the EHR system (S.Figure.1).



**S.Figure.1.** Main Interface to login and logout the MAV-clic

No.	Feature	Description
S.1.A	Main Menu	<p>Main top-down menu consists of six components as follows:</p> <ul style="list-style-type: none"> <li>File <ul style="list-style-type: none"> <li>Exit</li> </ul> </li> <li>Users <ul style="list-style-type: none"> <li>Institutes</li> </ul> </li> </ul>

		<ul style="list-style-type: none"> <li>• Employees</li> <li>• Roles</li> <li>• Admin</li> <li>• Analysis <ul style="list-style-type: none"> <li>• MAV-clic Eye</li> <li>• MAV-clic Measurement Analyzer</li> </ul> </li> <li>• Measures <ul style="list-style-type: none"> <li>• Measures</li> <li>• Version</li> <li>• Denominator</li> <li>• Numerator</li> <li>• Reports</li> </ul> </li> <li>• Databases <ul style="list-style-type: none"> <li>• Databases</li> <li>• Tables</li> </ul> </li> <li>• Help <ul style="list-style-type: none"> <li>• Contact</li> </ul> </li> </ul>
S.1.B	Login Information	The user enters user name and password to login to MAV-clic.
S.1.C	Log In/Out	<p>After log-in, the user has four options to choose.</p> <ul style="list-style-type: none"> <li>• Team Chat</li> <li>• Help</li> <li>• Logout</li> <li>• Close</li> </ul>

**S.Table.1.** Main Interface to login and logout the MAV-clic

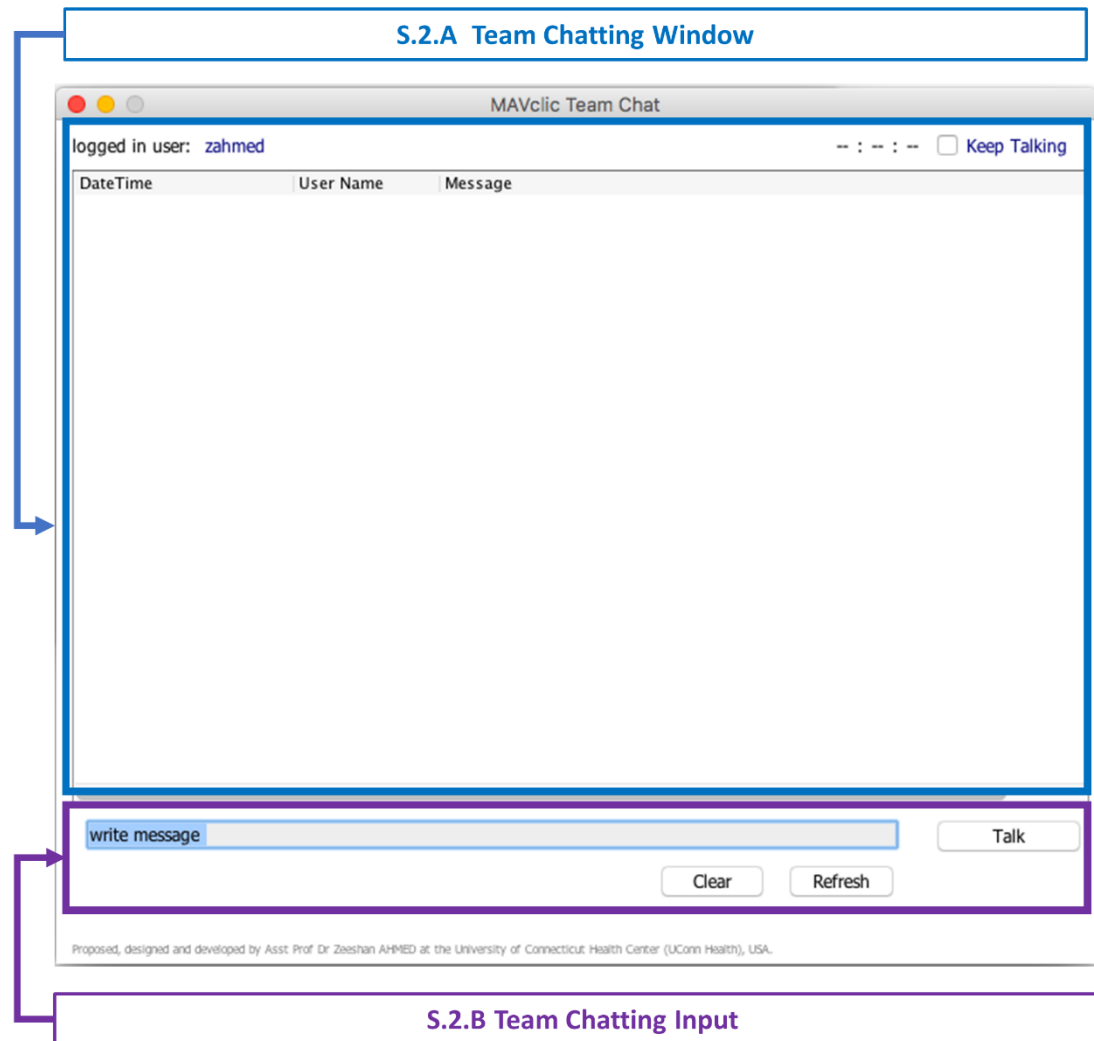
“Login” offers HIPAA compliant users authentication process. When a user logs into the MAV-clic system, a user must provide combinations of a user name (created by the MAV-clic administrator) and password (contains at least six characters long, include at least one number, include at least one symbol, must not contain the user ID, must be different from previous passwords, required to be changed at least once with in every 90 days). At successful login, it notifies user about password expiration 30 days before. “Login” tab also offer following options:

1. Logout from session
2. Get administrator’s contact information for help (For assistance and troubleshooting please write at: zahmed@uchc.edu OR please call at: 860-679-2643)
3. Team Chat (a module to connect all logged in users to exchange messages)
4. Close application (including all open relevant modules).

All the features of Main are presented in S.Figure.1 and explained in TableS.1.

## MAV-clc Team Chat:

After a logon, user can participate in conversations with other team members by pushing the “Team Chat” button (seen in S.1.C). S.Figure2 presents all the information made in the team chatting window.



**S.Figure.2.** Team Chatting Window

No.	Feature	Description
S.2.A	Team Chatting Window	Displays the conversation <ul style="list-style-type: none"> <li>“Keep Talking” Button: Check the option button to activate a “Keep Talking” function. If the button is checked, the conversation time will be recorded.</li> </ul>
S.2.B	Team Chatting Input	Write the message <ul style="list-style-type: none"> <li>“Talk” Button: Send the message.</li> <li>“Clear” Button: Clear all the conversation texts in the window.</li> <li>“Refresh” Button: Restore the cleared message in the window</li> </ul>

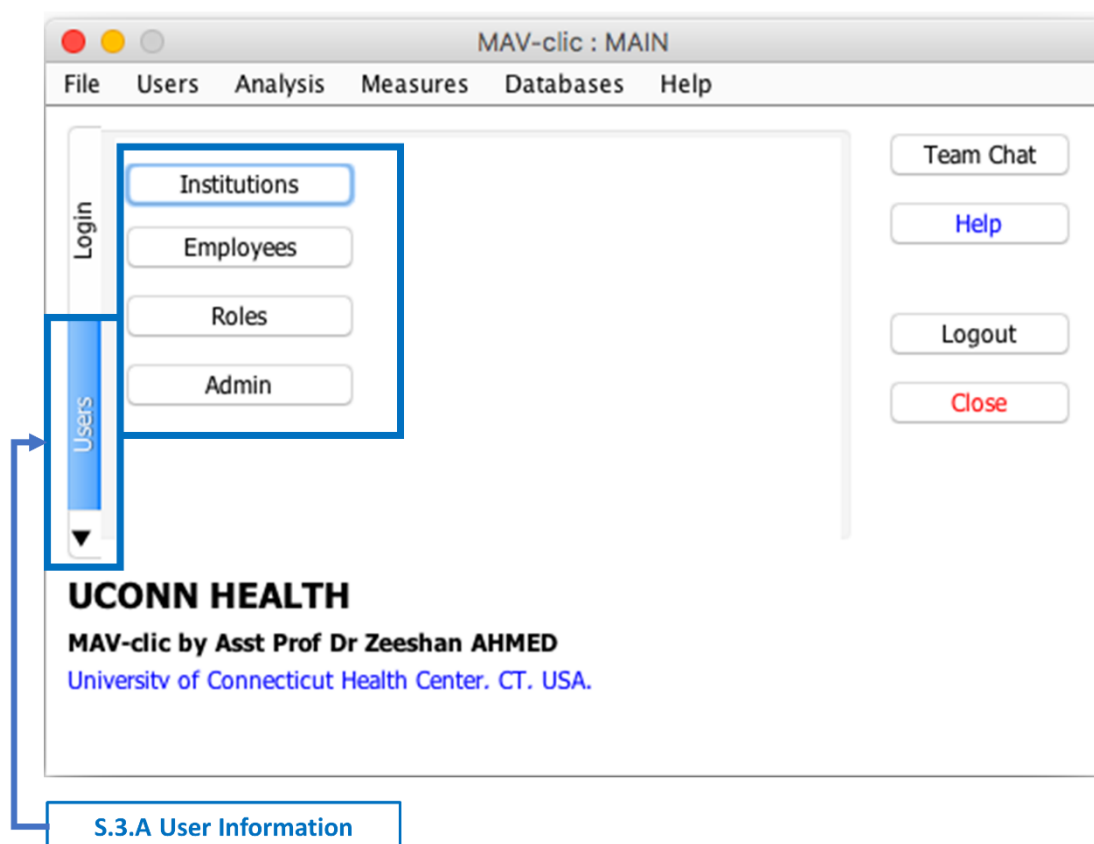
**S.Table.2.** Team Chatting Window

## User Data Management with MAV-clc

“Users” module helps in managing the data about all institutions (direct or collaborators) and employees playing different roles. It also helps in creating user accounts for all employees interacting with MAV-clc by setting access permissions and give updates for the logged events (operations performed by users).

Each user account has its own collection of settings in terms of the institution, role in the institution, and personal information (name, email, and office location). Users tab helps to create and manage the users’ information. In the institutions (S.Figure.4), and Roles (S.Figure.5) sections, all the information of institutions and roles are created. The created information is used to complete the employee information as seen in S.Figure6.

The “Admin” section can help system manger to manage the user login information using the following two tabs: User login management (S.Figure.7) & User login history (S.Figure.8). In the user login management tab, the system manager can create the user login information and assign the permissions in using the system. In the login history information, the history information can help the system manager can monitor users activity. The information can be used to analyze the performance of the system as well as to know which users have been inactive for a while.



**S.Figure.3.** “Users” Tab in the MAV-clc

No.	Feature	Description
S.3.A	User Information	<p>In the “Users” tab, you can manage the user profile using following buttons:</p> <ul style="list-style-type: none"> <li>• Institutions</li> <li>• Employees</li> <li>• Roles</li> <li>• Admin</li> </ul>

**S.Table.3.** “Users” Tab in the MAV-clc

### Institutions:

This is sub-module of Users. It offers features to collect and maintain information about institutions. The features are presented in S.Figure.4 and explained in S.Table.4.

The screenshot shows the MAV-clc : Institution window. It includes a sidebar for S.4.A Institution Information with fields for Name, Address, Email, Phone, Fax, Description, and DateTime. The main area contains S.4.C Institution Table with a table of institution data. Below the table are S.4.B Table Basic Functions (Modify, Create, Archive, Import, Export, Clear, Refresh) and S.4.D Table Data Option (Show archived data as well, Institution search field, Search button).

ID	Name	Address	Email	Phone	Fax	Description	DateTime
1	UConn Health	195 Farmington Ave	zahmed@uchc.edu	860-679-2643	NA	University of Conne...	2017-11-27 12:5...
2	UMASS	Amherst, MA	NA	NA	NA	NA	2017-11-27 12:3...
3	UConn Storrs	Storrs, CT	NA	NA	NA	Storrs Regional Ca...	2017-11-27 12:4...

**S.Figure.4.** Institution Information in the “Users” Menu

No.	Feature	Description
S.4.A	Institution Information	<p>Create the institution information.</p> <ul style="list-style-type: none"> <li>• Name,</li> <li>• Address,</li> <li>• Email</li> <li>• Phone</li> <li>• Fax.</li> <li>• Description</li> </ul>
S.4.B	Table Basic Functions	<ul style="list-style-type: none"> <li>• Create: To create the new entry.</li> <li>• Modify: To modify existing, selected data.</li> <li>• Archive: To archive existing, selected data.</li> <li>• Export: To export data in Microsoft Excel spreadsheet.</li> <li>• Import: To import data from Microsoft Excel spreadsheet.</li> <li>• Clear: To clear text fields.</li> </ul>



		<ul style="list-style-type: none"> <li>Refresh: To refresh and new updates (if exists) data.</li> </ul>
S.4.C	Institution Table	Displays the institution table.
S.4.D	Table Data Option	<ul style="list-style-type: none"> <li>“Show archived data as well”: Check “Show archived data as well” option to retrieve the archived data.</li> <li>Institution: Enter the existing institution information to search and retrieve the related information from the table (S.4.C).</li> </ul>

**S.Table.4.** Institution Information in the “Users” Menu.

## Roles:

This is sub-module of Users. It offers features to collect and maintain information about roles of employees. The features are presented in S.Figure.5 and explained in S.Table.5.

The screenshot shows the MAV-clc Roles module. On the left, the 'S.5.A Role Information' section has a form with the following data: ID: 6, Title: Dean, Description: Dean School of Medicine, and DateTime: 2017-11-30 09:20:17.0. Below the form are buttons for Modify, Create, Import, Archive, Export, Clear, and Refresh. On the right, the 'S.5.B Role Table' section displays a table with the following data:

ID	Title	Description	DateTime
1	Asst-Prof	Assistant Professor	2017-11-13 13:26:43.0
2	DA	Data Analyst	2017-11-30 09:20:48.0
3	SE	Software Engineering	2017-11-30 09:21:07.0
4	DA	Data Analyst	2017-11-30 09:21:18.0
5	DS	Data Scientist	2017-11-30 09:21:24.0
6	Dean	Dean School of Medicine	2017-11-30 09:20:17.0

At the bottom of the interface, there is a checkbox for 'Show archived data as well.', a search bar with the label 'Role', and a Search button.

**S.Figure.5.** Role Information in the “Users” Menu

No.	Feature	Description
S.5.A	Role Information	<p>Create the roles (positions) of the users in the institution. i.e.) data scientist, medical doctor, statistician, etc.</p> <p>Fields:</p> <ul style="list-style-type: none"> <li>Title</li> <li>Description</li> </ul>
S.5.B	Role Table	Displays the user’s role information.
	Basic Functions	<ul style="list-style-type: none"> <li>Create: To create the new entry.</li> <li>Modify: To modify existing, selected data.</li> <li>Archive: To archive existing, selected data.</li> <li>Export: To export data in Microsoft Excel spreadsheet.</li> <li>Import: To import data from Microsoft Excel spreadsheet.</li> <li>Clear: To clear text fields.</li> </ul>

		<ul style="list-style-type: none"> <li>• Refresh: To refresh and new updates (if exists) data.</li> <li>• Search: To search and retrieve the related data to the role information users entered in a search text field.</li> </ul>
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**S.Table.5.** Role Information in the “Users” Menu

## Employees:

This is sub-module of Users. It offers features to collect and maintain information about employees. It's all features are presented in S.Figure.6 and explained in S.Table.6.

The screenshot displays the MAV-clc: Employee interface. On the left, the 'S.6.A Employee Information' form is highlighted with a blue box. It contains fields for ID (1), First Name (Zeeshan), Last Name (Ahmed), Office (Uc30811), Email (zahmed@uchc.edu), Description (Scientist), Institute (1:UCONN Health), and Role (1:Asst-Prof). Below these fields are buttons for Modify, Create, Archive, Import, Export, Clear, and Refresh. On the right, the 'S.6.C Employee Table' is highlighted with a purple box. It shows a table with columns: ID, First Name, Last Name, Office, Email, Description, DateTime, Institution\_ID, and EmployeeRole\_ID. The table contains three rows of data. At the bottom of the interface, there is a checkbox for 'Show archived data as well.', a search bar labeled 'Employee', and a 'Search' button.

ID	First Name	Last Name	Office	Email	Description	DateTime	Institution_ID	EmployeeRole_ID
1	Zeeshan	Ahmed	Uc30811	zahmed@uchc.edu	Scientist	2017-11-30 09:...	1	1
2	Bruce	Liang	UConn Health	liang@uchc.edu	Dean	2017-11-30 09:...	1	6
3	Minjung	Kim	NA	mikim@uchc.edu	Scientists	2017-11-30 09:...	1	1

**S.Figure.6.** Employee Information in the “Users” Menu

No.	Feature	Description
S.6.A	Employee Information	<p>Create the user information. Once the institution and roles information are created, you can select user's institution and role using drop-down menu.</p> <p>Fields:</p> <ul style="list-style-type: none"> <li>• First Name</li> <li>• Last Name</li> <li>• Office</li> <li>• Email</li> <li>• Description</li> <li>• Institute</li> <li>• Role</li> </ul>
S.6.B	Employee Table	Displays the user's information
	Table Basic Functions	<ul style="list-style-type: none"> <li>• Create: To create the new entry.</li> <li>• Modify: To modify existing, selected data.</li> <li>• Archive: To archive existing, selected data.</li> <li>• Export: To export data in Microsoft Excel spreadsheet.</li> <li>• Import: To import data from Microsoft Excel spreadsheet.</li> </ul>

		<ul style="list-style-type: none"> <li>• Clear: To clear text fields.</li> <li>• Refresh: To refresh and new updates (if exists) data.</li> <li>• Search: To search and retrieve the related data to the employee information users entered in a search text field.</li> </ul>
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**S.Table.6.** Employee Information in the “Users” Menu

### Admin:

This is one of the most important sub-modules of Users. It offers features to create user accounts by selecting already created employees (S.Figure.6), set/update password and set permissions to access sub-modules of MAV-clc. It also offers features to get information about all logged events. The features are presented in S.Figure.7 and 8, and explained in S.Table.7 and 8.

The screenshot displays the MAV-clc User Login & Permissions interface. At the top, there are two tabs: 'User Login Management' and 'User Login History'. Below the tabs, there is a search bar and a 'Show archived data as well' checkbox. The main area contains a table with user login information. The table has columns for ID, First Name, and Last Name. Below the table, there are several sections: 'S.7.A Table Data Option' (top left), 'S.7.B User Login Table' (top right), 'S.7.C User Login' (bottom left), and 'S.7.D User Permission' (bottom right). The 'S.7.C User Login' section includes fields for User Name, Password, Question, and Answer. The 'S.7.D User Permission' section includes checkboxes for Admin, Users Management, and Analysis, and a 'Show IP Address' button.

**S.Figure.7.** User Login Management in the “Users” Menu

No.	Feature	Description
S.7.A	Table Data option	<ul style="list-style-type: none"> <li>• “Show archived data as well”: Check the option to retrieve the archived data.</li> <li>• “Users”: Enter a term to search and retrieve the related information from the table (S.7.B)</li> </ul>
S.7.B	User Login Table	Displays user login information in a table format.
S.7.C	User Login	Create user login information. <ul style="list-style-type: none"> <li>• Username: must be different from users/employee’s first and last name.</li> </ul>

		<ul style="list-style-type: none"> <li>• Password: should be at least six characters long, include at least one number, include at least one symbol ( _&amp;!%^&lt;&gt;*=-; ), must not contain the user ID, must be different from previous passwords, required to be changed at least once with in every 90 days.</li> <li>• Question: user proposed question, which can be used to verify user in case of losing or forgetting password.</li> <li>• Answer: user proposed answer to set question.</li> </ul>
S.7.D	User Permission	<p>Specify the tasks and features user can perform</p> <ul style="list-style-type: none"> <li>• Admin: Check the option to get administrative privileges.</li> <li>• User Management: Check the option to manage the user information (institution, employees, and roles) and measures information (measures, measures versions, measure version denominator, and measure version numerator).</li> <li>• Analysis: Check the option to use “Analysis” menu.</li> <li>• Block: If this option checked, the selected person restrict to use main menus.</li> <li>• Show IP Address: Displays a unique identifying IP address.</li> </ul>
	Table Basic Functions	<ul style="list-style-type: none"> <li>• Create: To create the new entry.</li> <li>• Modify: To modify existing, selected data.</li> <li>• Clear: To clear text fields.</li> </ul>

**S.Table.7.** User Login Management in the “Users” Menu

**S.8.A Table Data Option**

**S.8.B Login History Table**

ID	User	Date Time	Operation	IP Address
296948	dm	2017-11-30 13:55:05.0	*** SELECT * FROM	0
296949	dm	2017-11-30 13:55:05.0	*** SELECT * FROM	0
296950	dm	2017-11-30 13:55:05.0	*** SELECT * FROM	0
296951	dm	2017-11-30 13:55:05.0	*** SELECT * FROM	0
296952	dm	2017-11-30 13:55:05.0	*** SELECT * FROM	0
296953	dm	2017-11-30 13:55:05.0	*** SELECT * FROM	0
296954	dm	2017-11-30 13:55:05.0	*** SELECT * FROM	0
296955	dm	2017-11-30 13:55:05.0	*** SELECT * FROM	0
296956	dm	2017-11-30 13:55:05.0	*** SELECT * FROM	0
296957	dm	2017-11-30 13:55:05.0	*** SELECT * FROM	0
296958	dm	2017-11-30 13:55:05.0	*** SELECT * FROM	0
296959	dm	2017-11-30 13:55:05.0	*** SELECT * FROM	0
296960	dm	2017-11-30 13:55:05.0	*** SELECT * FROM	0
296961	dm	2017-11-30 13:55:05.0	*** SELECT * FROM	0
296962	dm	2017-11-30 13:55:05.0	*** SELECT * FROM	0
296963	dm	2017-11-30 13:55:05.0	*** SELECT * FROM	0
296964	dm	2017-11-30 13:55:05.0	*** SELECT * FROM	0
296965	dm	2017-11-30 13:55:05.0	*** SELECT * FROM	0
296966	dm	2017-11-30 13:55:05.0	*** SELECT * FROM	0
296967	dm	2017-11-30 13:55:05.0	*** SELECT * FROM	0
296968	dm	2017-11-30 13:55:05.0	*** SELECT * FROM	0
296969	dm	2017-11-30 13:55:05.0	*** SELECT * FROM	0
296970	dm	2017-11-30 13:55:05.0	*** SELECT * FROM	0
296971	dm	2017-11-30 13:55:05.0	*** SELECT * FROM	0
296972	dm	2017-11-30 13:55:05.0	*** SELECT * FROM	0
296973	dm	2017-11-30 13:55:05.0	*** SELECT * FROM	0
296974	dm	2017-11-30 13:55:05.0	*** SELECT * FROM	0
296975	dm	2017-11-30 13:55:05.0	*** SELECT * FROM	0
296976	dm	2017-11-30 13:55:05.0	*** SELECT * FROM	0
296977	dm	2017-11-30 13:55:05.0	*** SELECT * FROM	0
296978	dm	2017-11-30 13:55:05.0	*** SELECT * FROM	0
296979	dm	2017-11-30 13:55:05.0	*** SELECT * FROM	0
296980	dm	2017-11-30 13:55:05.0	*** SELECT * FROM	0
296981	dm	2017-11-30 13:55:05.0	*** SELECT * FROM	0
296982	dm	2017-11-30 15:00:16.0	Exit	0
296983	dm	2017-12-01 14:15:05.0	Login	0
296984	dm	2017-12-01 14:15:14.0	Database_Tables	0
296985	dm	2017-12-01 14:15:37.0	Database	0
296986	dm	2017-12-01 14:16:48.0	Database	0
296987	dm	2017-12-01 14:39:59.0	MAV-clc_Measurement_Analyzer	0
296988	dm	2017-12-01 17:06:20.0	Exit	0
296989	dm	2017-12-04 08:43:13.0	Login	0
525809	dm	2017-12-04 14:41:05.0	Exit	0

**S.Figure.8.** User Login History in the “Users” Menu

No.	Feature	Description
S.8.A	Table Data option	<ul style="list-style-type: none"> <li>• “Refresh”: Refresh the searched information and show it in the table (S.8.B).</li> </ul>

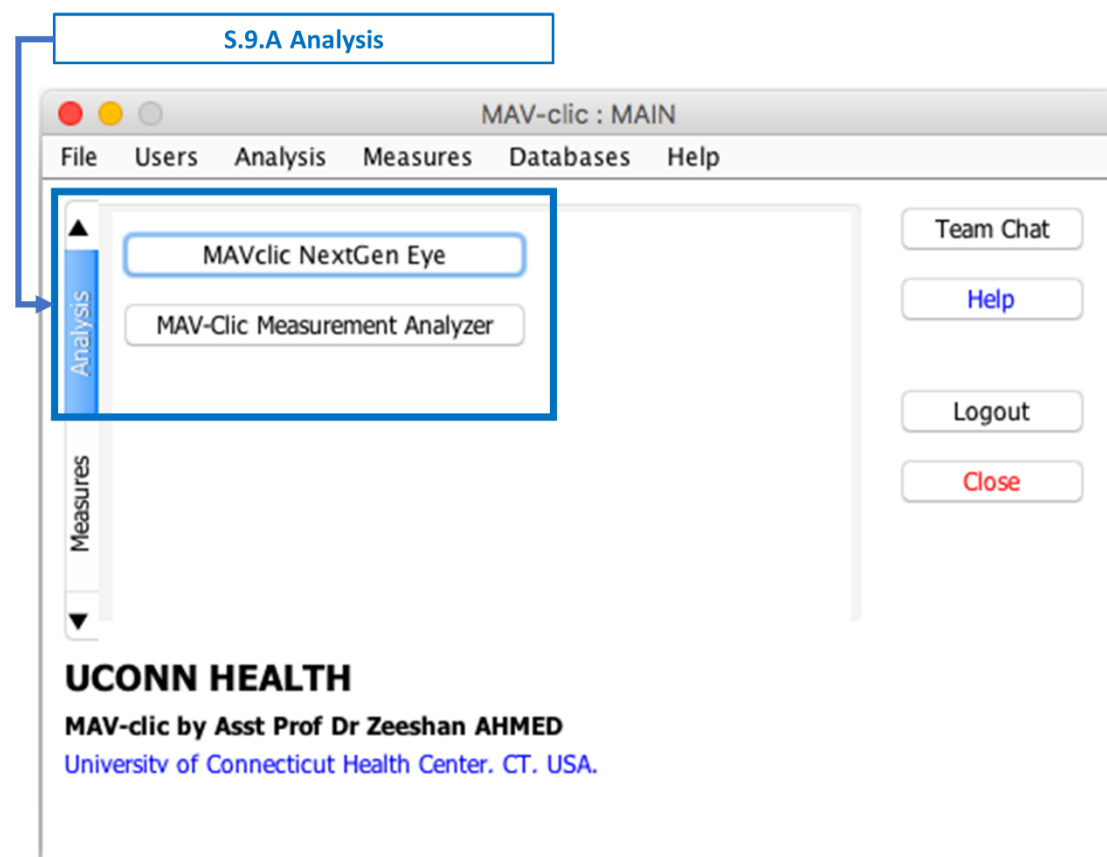
		<ul style="list-style-type: none"> <li>• “Export”: Export the user login information from Microsoft Excel spreadsheet (.xlsx).</li> <li>• “Users/ Operation”: Enter user/operation term to search and retrieve related information from the table (S.8.B).</li> </ul>
S.8.B	Login History Table	Displays summary table of all logins, sorted from the oldest to the newest.
	Table Basic Functions	<ul style="list-style-type: none"> <li>• Search: To search data based in entered keyword in search text field.</li> </ul>

216 **S.Table.8.** User Login History in the “Users” Menu.

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## Analyzing and Visualizing the Clinical Data

The Analysis tab (S.Figure.9 and S.Table.9) offers two buttons: MAV-clc NextGen Eye, and MAV-clc Measurement Analyzer. The major functions in the MAV-clc NextGen Eye is to look into the clinical data based on the customized selections in term of personal and regional information, medication, and lab results in a single database while the main role of MAV-clc Measurement Analyzer is to calculate the quality measure using clinical data stored in multiple EHR databases.



**S.Figure.9.** “Analysis” Tab in the MAV-clc

No.	Feature	Description
S.9.A	Analysis	<p>In the “Analysis” tab, you can choose one of followings:</p> <ul style="list-style-type: none"> <li>Measures NextGen Eye: Select “MAV-clc NextGen Eye” button to look over the patient information sorted out based on the selected criteria.</li> <li>MAV-clc Measurement Analyzer: Select “MAV-clc Measurement Analyzer” button to build the cohort, evaluate quality measures, and make a report.</li> </ul>

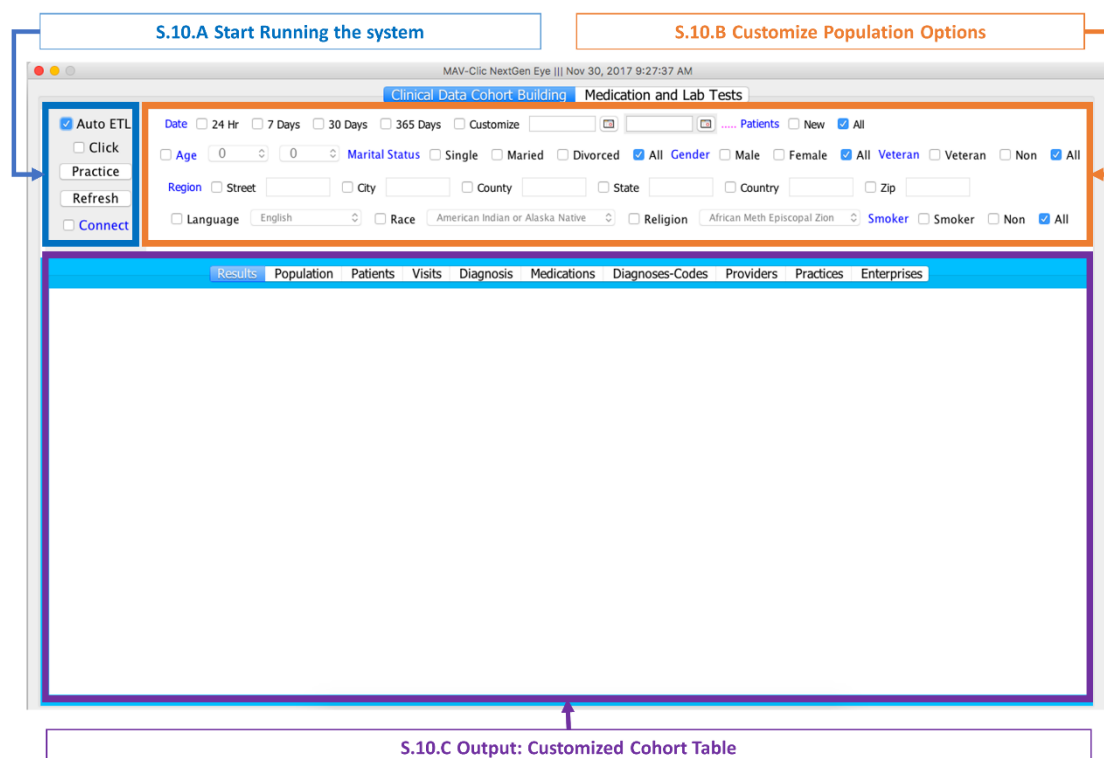
**S.Table.9.** “Analysis” Tab in the MAV-clc

### MAV-clc NextGen Eye:

This is the sub-module of Analysis which allows user to connect to the NextGen relational database and to analyze the patients’ clinical information in a viewpoint of the healthcare

providers. . It is further divided in to two additional sub-modules, 1) Clinical Data Cohort building (S.Figure10), and 2) Medication and Lab Test (S.Figure11).

Before starting analysis, user is required to firstly, connect (S. Figure. 10A) to the NextGen relational database by checking “Connect” (blue color text), and at successful connection it will turn in to “Disconnect” (red color text). Then in case user would like to automatically draw ontological relationships between extracted patients based data (e.g. total pollution → patients → visits → diagnoses → provided medications → providers who treated patients → practice → enterprise), it’s required to check option “Auto ETL”. Lastly, user can practice based information by pressing button “Practice” and can perform new analysis by pressing button “Refresh”.



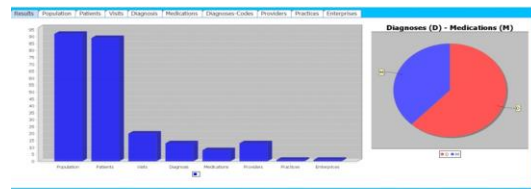
**S.Figure.10.** Clinical Data Cohort Building in MAV-clic NextGen Eye

No.	Feature	Description
S.10.A	Start Running the system	<ul style="list-style-type: none"> <li>Auto ETL: If this option is checked, ETL processes will be executed following the sequence of “Population&gt; Patients &gt; Visit&gt; Diagnosis”. If it is not checked, the system will perform the analysis based on user’s input. The user should manually select the sequence to obtain the analysis results.</li> <li>Click: Checking the option, users can select a particular patient of interest and track the patient information from the tabs in the “Output” section (S.10.C).</li> <li>Practice: Displays all the provider information stored in the MAV-clic.</li> <li>Refresh: Refreshes the result based on the changes made in options (S.10.B).</li> <li>Connect: if this option is checked, MAV-clic connects with the database.</li> </ul>

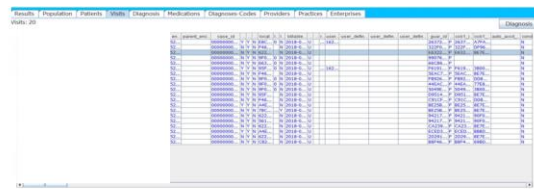
S.10.B	Customize Population Option	<p>Customize the population of interest with ten different options. All options except Date are selected at default.</p> <ul style="list-style-type: none"> <li>• Patients <ul style="list-style-type: none"> <li>○ Search among new patients only</li> <li>○ Search among all patients (new and old)</li> </ul> </li> <li>• Date, day and hours: <ul style="list-style-type: none"> <li>○ 24 Hour</li> <li>○ 7 days</li> <li>○ 365 days</li> <li>○ Customize <ul style="list-style-type: none"> <li>▪ Start date</li> <li>▪ End date</li> </ul> </li> </ul> </li> <li>• Age <ul style="list-style-type: none"> <li>○ Start age</li> <li>○ End age</li> </ul> </li> <li>• Marital Status <ul style="list-style-type: none"> <li>○ Single</li> <li>○ Married</li> <li>○ Divorced</li> <li>○ All</li> </ul> </li> <li>• Gender <ul style="list-style-type: none"> <li>○ Male</li> <li>○ Female</li> <li>○ All</li> </ul> </li> <li>• Veteran <ul style="list-style-type: none"> <li>○ Veteran</li> <li>○ Non</li> <li>○ All</li> </ul> </li> <li>• Smoker <ul style="list-style-type: none"> <li>○ Smoker</li> <li>○ Non</li> <li>○ All</li> </ul> </li> <li>• Region <ul style="list-style-type: none"> <li>○ Street</li> <li>○ City</li> <li>○ County</li> <li>○ State</li> <li>○ Country</li> <li>○ Zip</li> </ul> </li> <li>• Language</li> <li>• Race</li> <li>• Religion</li> </ul>
S.10.C	Output: Customized Population	<p>Provides population information sorted out based on the selected criteria. MAV-clic offers ten output tabs having different perspectives in the defined population.</p> <ul style="list-style-type: none"> <li>• Results <ul style="list-style-type: none"> <li>○ Bar chart showing the frequencies from the results (population, patients, visits, diagnosis, medication, providers, practices, and enterprises)</li> <li>○ Pie chart having the frequency ratio of diagnoses vs. medications</li> </ul> </li> <li>• Population <ul style="list-style-type: none"> <li>○ All the people who entered in the EHR system</li> <li>○ Fields <ul style="list-style-type: none"> <li>▪ ID information: Person (Patient) ID, Practice ID, Enterprise ID.</li> <li>▪ Demographics: Name, Address, Race, Data of Birth etc.</li> </ul> </li> </ul> </li> <li>• Patients <ul style="list-style-type: none"> <li>○ All the patients who registered to receive the treatment</li> </ul> </li> </ul>



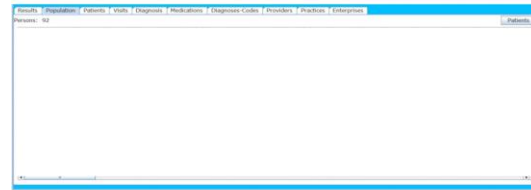
		<ul style="list-style-type: none"> <li>○ Field <ul style="list-style-type: none"> <li>▪ ID information: Person (Patient) ID, Practice ID, Enterprise ID.</li> <li>▪ Time stamp information: Time information using EHR system</li> </ul> </li> <li>• Visits <ul style="list-style-type: none"> <li>○ All the patients who visit the health providers</li> <li>○ Field <ul style="list-style-type: none"> <li>▪ ID information: Person (Patient) ID, Practice ID, Enterprise ID, Encounter Id, Provider ID, Location ID, Case ID</li> <li>▪ Encounter time stamp information</li> <li>▪ Payment information</li> </ul> </li> </ul> </li> <li>• Diagnosis <ul style="list-style-type: none"> <li>○ All the diagnosis information which are made during the health provider visit</li> <li>○ Fields <ul style="list-style-type: none"> <li>▪ ID information: Person (Patient) ID, Practice ID, Enterprise ID, Encounter Id, Provider ID, Location ID, Case ID, Diagnosis code library ID</li> <li>▪ Diagnosis related time stamp information</li> <li>▪ Diagnosis information: Diagnosis code, ICD-9 code, Diagnosis description etc.</li> </ul> </li> </ul> </li> <li>• Medications <ul style="list-style-type: none"> <li>○ All the medication which are made during the health provider visit</li> <li>○ Fields <ul style="list-style-type: none"> <li>▪ ID information: Person (Patient) ID, Practice ID, Enterprise ID, Encounter Id, Provider ID, Location ID, Case ID, NDC (National Drug Code) ID, Diagnosis Library ID</li> <li>▪ Medication related time stamp information</li> <li>▪ Medication information: Rx quantity, Rx refills, Rx unit, Rx comment etc.</li> </ul> </li> </ul> </li> <li>• Diagnosis-Codes <ul style="list-style-type: none"> <li>○ All the diagnosis information stored in the database</li> <li>○ Fields <ul style="list-style-type: none"> <li>▪ Diagnosis code library ID</li> <li>▪ Diagnosis code</li> <li>▪ ICD-9 code</li> <li>▪ Diagnosis description</li> </ul> </li> </ul> </li> <li>• Providers <ul style="list-style-type: none"> <li>○ All the healthcare providers who treat patients</li> <li>○ Fields <ul style="list-style-type: none"> <li>▪ ID information: Provider ID</li> <li>▪ Contact Information: Name, Address, Telephone number, Email, Fax etc.</li> </ul> </li> </ul> </li> <li>• Practices <ul style="list-style-type: none"> <li>○ All the healthcare practices that patients use</li> <li>○ Fields <ul style="list-style-type: none"> <li>▪ ID information: Enterprise ID, Practice ID</li> <li>▪ Contact Information: Name, Address, Telephone number, Email, Fax etc.</li> </ul> </li> </ul> </li> <li>• Enterprises <ul style="list-style-type: none"> <li>○ All the healthcare enterprises that are composed of healthcare practices</li> <li>○ Fields <ul style="list-style-type: none"> <li>▪ ID information: Enterprise ID</li> <li>▪ Enterprise related time stamp information</li> </ul> </li> </ul> </li> </ul>
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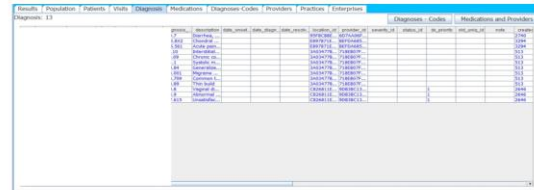
S.Figure.10.1 Results Tab in the Cohort Table



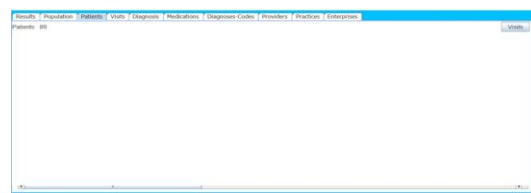
S.Figure.10.4 Visits Tab in the Cohort Table



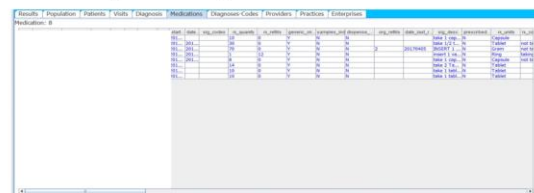
S.Figure.10.2 Population Tab in the Cohort Table



S.Figure.10.5 Diagnosis Tab in the Cohort Table

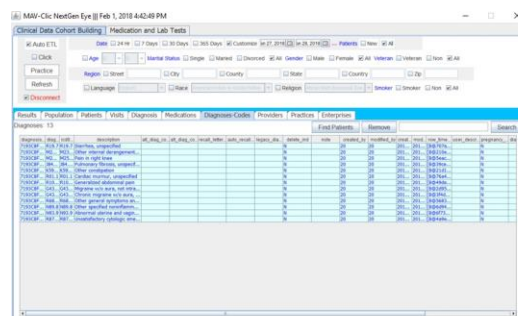


S.Figure.10.3 Patients Tab in the Cohort Table

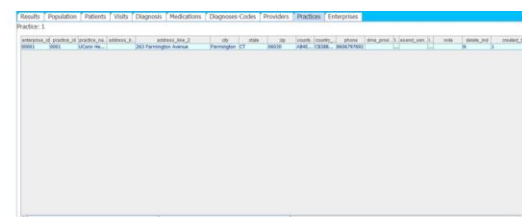


S.Figure.10.6 Medications Tab in the Cohort Table

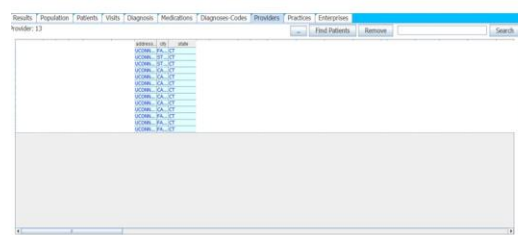
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248  
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250



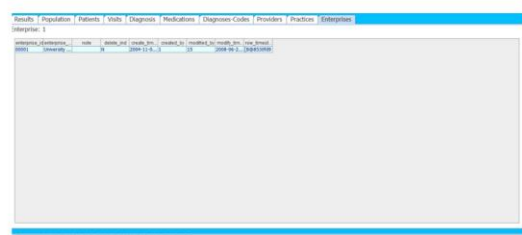
S.Figure.10.7 Diagnoses-Codes Tab in the Cohort Table



S.Figure.10.9 Practices Tab in the Cohort Table

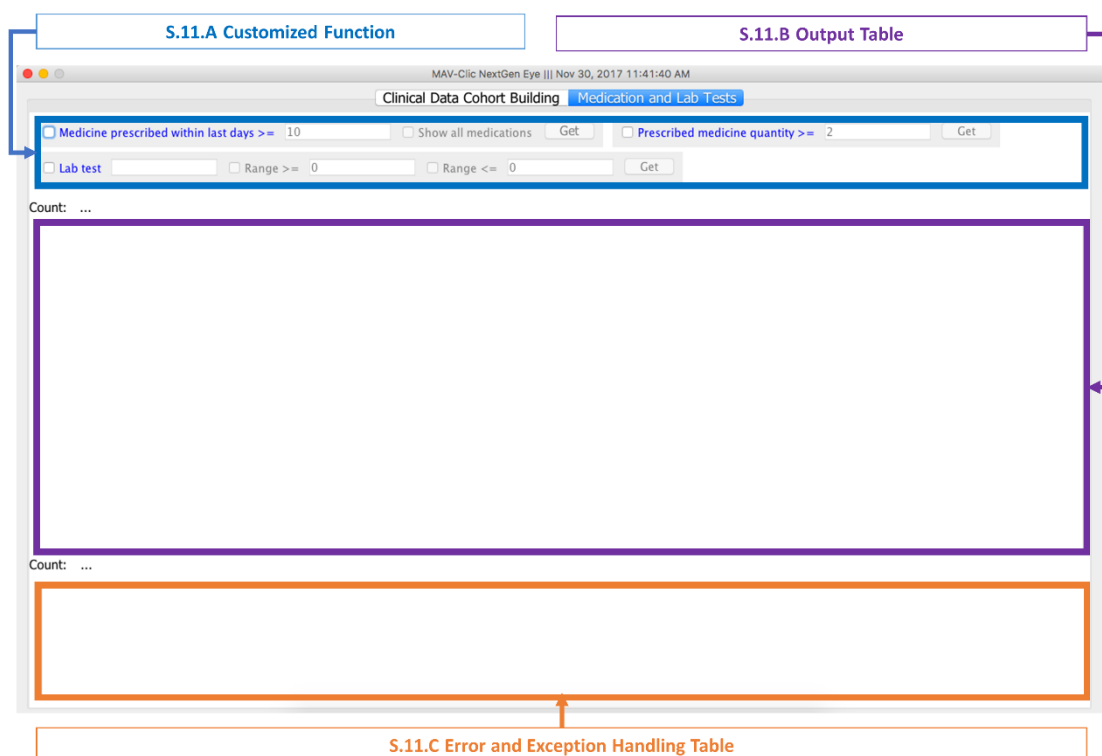


S.Figure.10.8 Providers Tab in the Cohort Table



S.Figure.10.10 Enterprises Tab in the Cohort Table

251  
252  
253



**S.Figure.11.** Medication and Lab Tests in MAV-clic NextGen Eye

No.	Feature	Description
S.11.A	Customized Function	<p>Customize the population with medication and lab test options.</p> <ul style="list-style-type: none"> <li>Medicine prescribed within last days <ul style="list-style-type: none"> <li>Medicine prescribed within last days: Check the option and input the number of the days to obtain the patients' medication information</li> <li>Show all medications: Check the option to obtain all the medication information.</li> </ul> </li> <li>Prescribed medicine quantity: Check the option and input the number of medicine quantity to get the patients' medication information</li> <li>Lab Test <ul style="list-style-type: none"> <li>Check the "Lab test" option and input the name of lab test to obtain the patients' lab test information</li> <li>Check the "Range &gt;=" and/or "Range &lt;=" option(s) to define the lowest and/or highest values of the lab test.</li> </ul> </li> </ul>
S.11.B	Output Table	Displays the patient information table
S.11.C	Error and Exceptional Handling Table	Displays the patient information table when the result is not-recommended format or is out of range in the lab test.

**S.Table.11.** Medication and Lab Tests in MAV-clic NextGen Eye

Users can customize the cohort conditions in terms of the personal information, regional information (as seen in S.Figure10.B) from the registered patient population. It is capable of tracking one specific patient in terms of visit to the practices, diagnoses, medication, and consulted providers. Once the cohort is built from the Clinical Data Cohort Building

(S.Figure.10), analyzers can look into details in terms of medications and lab test results as seen in the S.Figure.11.

#### MAV-clc Measurement Analyzer:

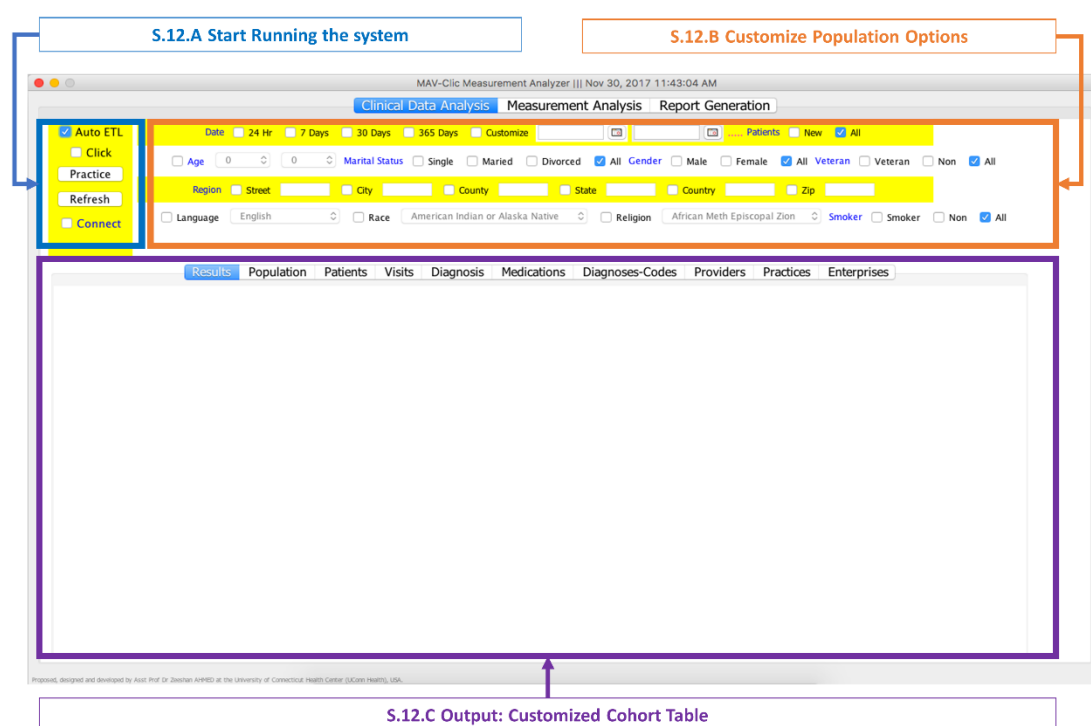
MAV-clc Measurement Analyzer is composed of three analysis and visualization submodules of 1) Clinical Data Analysis, 2) Measurement Analysis, and 3) Report Generation. In Clinical Data Analysis (S.Figure12), users can build group of patients by choosing the demographic and time points information same as the Clinical Data Cohort Building (S.Figure10) and by assigning the diagnosis of interest codes to the quality measure information.

Similar to the MAV-clc NextGen Eye, there are two preliminary steps prior to designing the initial patient population of interest. The first step is to check the “Connect” button in order to connect to the relational database. The second step is to check “Auto ETL” button to track the ontological relationships from the registered patient population in the database automatically. After selecting the design elements for group of patients, users can run the MAV-clc system by pressing the “Practice” button at the first analysis, and by pressing the “Refresh” button after the second analysis.

In calculating the quality measures, it is required to build the population at risk. The population at risk can be defined as diagnosis information. In the diagnosis-code tab (S.Figure12.8), users can 1) filter out the diagnosis codes of interest, 2) connect the codes with the measure, and measure versions, and 3) save the link in the server. The saved link information can narrow down the patient population satisfying the conditions of initial population which is the first step of evaluating the quality measures. The clinical information who are selected for quality measure evaluation can be downloaded with Microsoft Excel Spreadsheet (.xlsx).

Also, the population at risk can be defined by the medications use. The medications of interest can be searched in the medication tab in the cohort table (S.Figure12.7). Based on the selected lists of medication, the patients can be found by clicking a “Find Patients” button. Also, clinical information sorted out can be downloaded with Microsoft Excel Spreadsheet (.xlsx).

## Step-by-Step Guide to MAV-clc: Framework for the Health Care Data Analysis



**S.Figure.12.** Clinical Data Analysis in MAV-clc Measurement Analyzer

No.	Feature	Description
S.12.A	Start Running the System	<ul style="list-style-type: none"> <li>Auto ETL: If the option is checked, ETL processes will be executed following the sequence of "Population&gt; Patients &gt; Visit&gt; Diagnosis". If it is not checked, the system will perform the analysis based on user's input. The user should manually select the sequence to obtain the analysis results.</li> <li>Click: Checking the option, users can select a particular patient of interest and track the patient information from the tabs in the "Output" Tab (S.12.C).</li> <li>Practice: Displays all the provider information stored in the database.</li> <li>Refresh: Refreshes the result based on the changes made in options (S.12.B).</li> <li>Connect: if the option is checked, MAV-clc connects with the EHR database.</li> </ul>
S.12.B	Customize Population Options	<p>Customize the population of interest with ten different options. All options except Date are selected at default.</p> <ul style="list-style-type: none"> <li>Patients <ul style="list-style-type: none"> <li>Search among new patients only</li> <li>Search among all patients (new and old)</li> </ul> </li> <li>Date, day and hours: <ul style="list-style-type: none"> <li>24 Hour</li> <li>7 days</li> <li>365 days</li> <li>Customize <ul style="list-style-type: none"> <li>Start date</li> <li>End date</li> </ul> </li> </ul> </li> <li>Age <ul style="list-style-type: none"> <li>Start age</li> <li>End age</li> </ul> </li> <li>Marital Status</li> </ul>

		<ul style="list-style-type: none"> <li>○ Single</li> <li>○ Married</li> <li>○ Divorced</li> <li>○ All</li> <li>• Gender <ul style="list-style-type: none"> <li>○ Male</li> <li>○ Female</li> <li>○ All</li> </ul> </li> <li>• Veteran <ul style="list-style-type: none"> <li>○ Vetran</li> <li>○ Non</li> <li>○ All</li> </ul> </li> <li>• Smoker <ul style="list-style-type: none"> <li>○ Smoker</li> <li>○ Non</li> <li>○ All</li> </ul> </li> <li>• Region <ul style="list-style-type: none"> <li>○ Street</li> <li>○ City</li> <li>○ County</li> <li>○ State</li> <li>○ Country</li> <li>○ Zip</li> </ul> </li> <li>• Language</li> <li>• Race</li> <li>• Religion</li> </ul>
S.12.C	Output: Customized Cohort Table	<p>Provides patient population information sorted out based on the selected criteria. MAV-clic provides ten output tabs having different perspectives in the defined population. In each tab, the patient information can be saved as Microsoft Excel spreadsheet (.xlsx).</p> <ul style="list-style-type: none"> <li>• Summary: Unique numbers calculated in the systems <ul style="list-style-type: none"> <li>○ Unique number of patients</li> <li>○ Unique number of patients visited</li> <li>○ Unique number of visits</li> <li>○ Unique number of patients prescribed medications</li> <li>○ Unique number of prescribed medications</li> <li>○ Unique number of providers</li> <li>○ Unique number of diagnosis codes</li> <li>○ Unique number of icd9cm codes</li> <li>○ Unique number of practices where medications prescribed</li> </ul> </li> <li>• Results <ul style="list-style-type: none"> <li>○ Bar chart showing the frequencies from the results (population, patients, visits, diagnosis, medication, providers, practices, and enterprises)</li> <li>○ Pie chart having the frequency ratio of diagnoses vs. medications</li> </ul> </li> <li>• Population <ul style="list-style-type: none"> <li>○ All the people who entered in the EHR system</li> <li>○ Fields <ul style="list-style-type: none"> <li>▪ ID information: Person (Patient) ID, Practice ID, Enterprise ID.</li> <li>▪ Demographics: Name, Address, Race, Data of Birth etc.</li> </ul> </li> </ul> </li> <li>• Patients <ul style="list-style-type: none"> <li>○ All the patients who registered to receive the treatment</li> <li>○ Field <ul style="list-style-type: none"> <li>▪ ID information: Person (Patient) ID, Practice ID, Enterprise ID.</li> <li>▪ Time stamp information: Time information using EHR system</li> </ul> </li> </ul> </li> </ul>

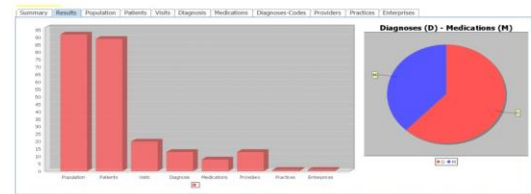
		<ul style="list-style-type: none"> <li>• Visits <ul style="list-style-type: none"> <li>○ All the patients who visit the health providers</li> <li>○ Field <ul style="list-style-type: none"> <li>▪ ID information: Person (Patient) ID, Practice ID, Enterprise ID, Encounter Id, Provider ID, Location ID, Case ID</li> <li>▪ Encounter time stamp information</li> <li>▪ Payment information</li> </ul> </li> </ul> </li> <li>• Diagnosis <ul style="list-style-type: none"> <li>○ All the diagnosis information which are made during the health provider visit</li> <li>○ Diagnosis Search Function <ul style="list-style-type: none"> <li>▪ Diagnosis name search</li> <li>▪ ICD-9 Code Search</li> </ul> </li> <li>○ Fields <ul style="list-style-type: none"> <li>▪ ID information: Person (Patient) ID, Practice ID, Enterprise ID, Encounter Id, Provider ID, Location ID, Case ID, Diagnosis code library ID</li> <li>▪ Diagnosis related time stamp information</li> <li>▪ Diagnosis information: Diagnosis code, ICD-9 code, Diagnosis description etc.</li> </ul> </li> </ul> </li> <li>• Medications <ul style="list-style-type: none"> <li>○ All the medication which are made during the health provider visit</li> <li>○ Medication Search Function <ul style="list-style-type: none"> <li>▪ Medication name search</li> <li>▪ NDC Code Search</li> </ul> </li> <li>○ Fields <ul style="list-style-type: none"> <li>▪ ID information: Person (Patient) ID, Practice ID, Enterprise ID, Encounter Id, Provider ID, Location ID, Case ID, NDC (National Drug Code) ID, Diagnosis Library ID</li> <li>▪ Medication related time stamp information</li> <li>▪ Medication information: Rx quantity, Rx refills, Rx unit, Rx comment etc.</li> </ul> </li> </ul> </li> <li>• Diagnosis-Codes <ul style="list-style-type: none"> <li>○ All the diagnosis information stored in the database</li> <li>○ Users can filter out the diagnosis codes of interest, save the codes in the relevant measures, and measure version, and save them in the database. This work enables to find out initial patient population for the quality measures.</li> <li>○ Fields <ul style="list-style-type: none"> <li>▪ Diagnosis code library ID</li> <li>▪ Diagnosis code</li> <li>▪ ICD-9 code</li> <li>▪ Diagnosis description</li> </ul> </li> </ul> </li> <li>• Providers <ul style="list-style-type: none"> <li>○ All the healthcare providers who treat patients</li> <li>○ Fields <ul style="list-style-type: none"> <li>▪ ID information: Provider ID</li> <li>▪ Contact Information: Name, Address, Telephone number, Email, Fax etc.</li> </ul> </li> </ul> </li> <li>• Practices <ul style="list-style-type: none"> <li>○ All the healthcare practices that patients use</li> <li>○ Practice Search Function <ul style="list-style-type: none"> <li>▪ Practice location search</li> <li>▪ Practice Specialty search</li> </ul> </li> <li>○ Fields <ul style="list-style-type: none"> <li>▪ ID information: Enterprise ID, Practice ID</li> <li>▪ Contact Information: Name, Address, Telephone number, Email, Fax etc.</li> </ul> </li> </ul> </li> <li>• Enterprises</li> </ul>
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		<ul style="list-style-type: none"> <li>○ All the healthcare enterprises that are composed of healthcare practices</li> <li>○ Fields <ul style="list-style-type: none"> <li>▪ ID information: Enterprise ID</li> <li>▪ Enterprise related time stamp information</li> </ul> </li> </ul>

**S.Table.12.** Clinical Data Analysis in MAV-clc Measurement Analyzer



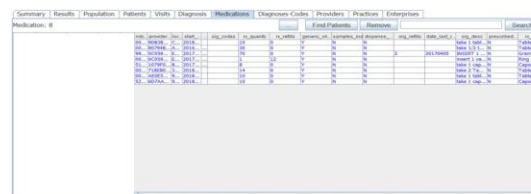
S.Figure.12.1 Summary Tab in the Cohort Table



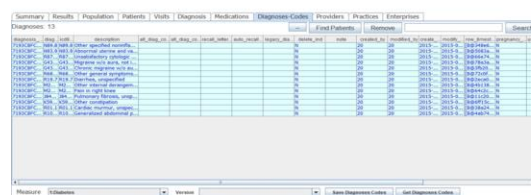
S.Figure.12.2 Results Tab in the Cohort Table



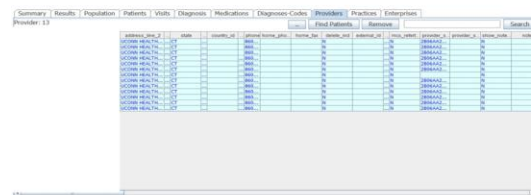
S.Figure.12.3 Population Tab in the Cohort Table



S.Figure.12.7 Medications Tab in the Cohort Table



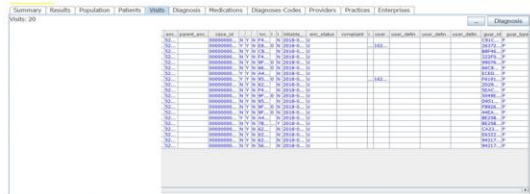
S.Figure.12.8 Diagnoses-Codes Tab in the Cohort Table



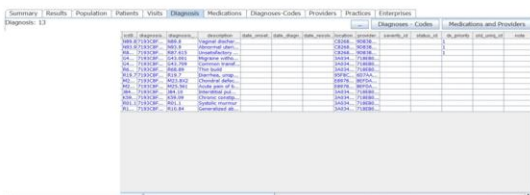
S.Figure.12.9 Providers Tab in the Cohort Table



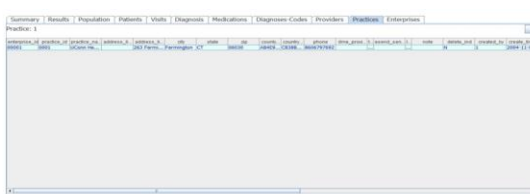
S.Figure.12.4 Patients Tab in the Cohort Table



S.Figure.12.5 Visits Tab in the Cohort Table



S.Figure.12.6 Diagnosis Tab in the Cohort Table

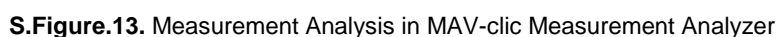


S.Figure.12.10 Practices Tab in the Cohort Table



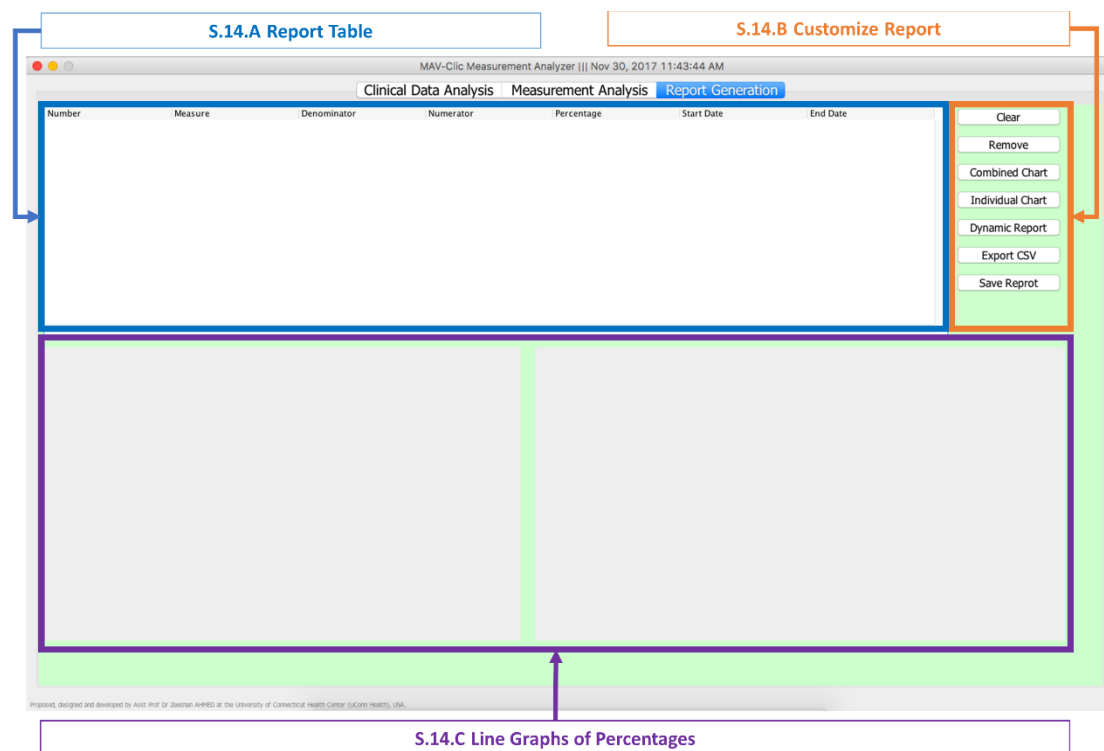
S.Figure.12.11 Enterprises Tab in the Cohort Table



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S.13.C	Error and Exception Handling Table	Displays the patient information table when the result is not-recommended format or is out of range in the lab test.
S.13.D	Pie Chart	Displays the numerical proportion of the selected patient information (S.13.B).
S.13.E	Add to Report	Click the button to move the patient information to the “Report Generation” tab.

**S.Table.13.** Measurement Analysis in MAV-clc Measurement Analyzer



**S.Figure.14.** Report Generation in MAV-clc Measurement Analyzer

No.	Feature	Description
S.14.A	Report Table	<p>Displays the summary information which was made in the “Measurement Analysis” tab. The report table contains 7 components as follows:</p> <ul style="list-style-type: none"> <li>• Number</li> <li>• Measure</li> <li>• Denominator: Number of Initial patient population (S.12.C)</li> <li>• Numerator: Number of cohort defined with medication and lab test options (S.13.B).</li> <li>• Percentage: Numerator/Denominator *100</li> <li>• Start Date</li> <li>• End Date</li> </ul>
S.14.B	Customize Report	<p>Customize the report table (S.14.A) with seven different options.</p> <ul style="list-style-type: none"> <li>• Clear: Clear all the information in the report table (S.14.A).</li> <li>• Remove: Remove the selected information in the report table (S.14.A).</li> <li>• Combined Chart</li> </ul>

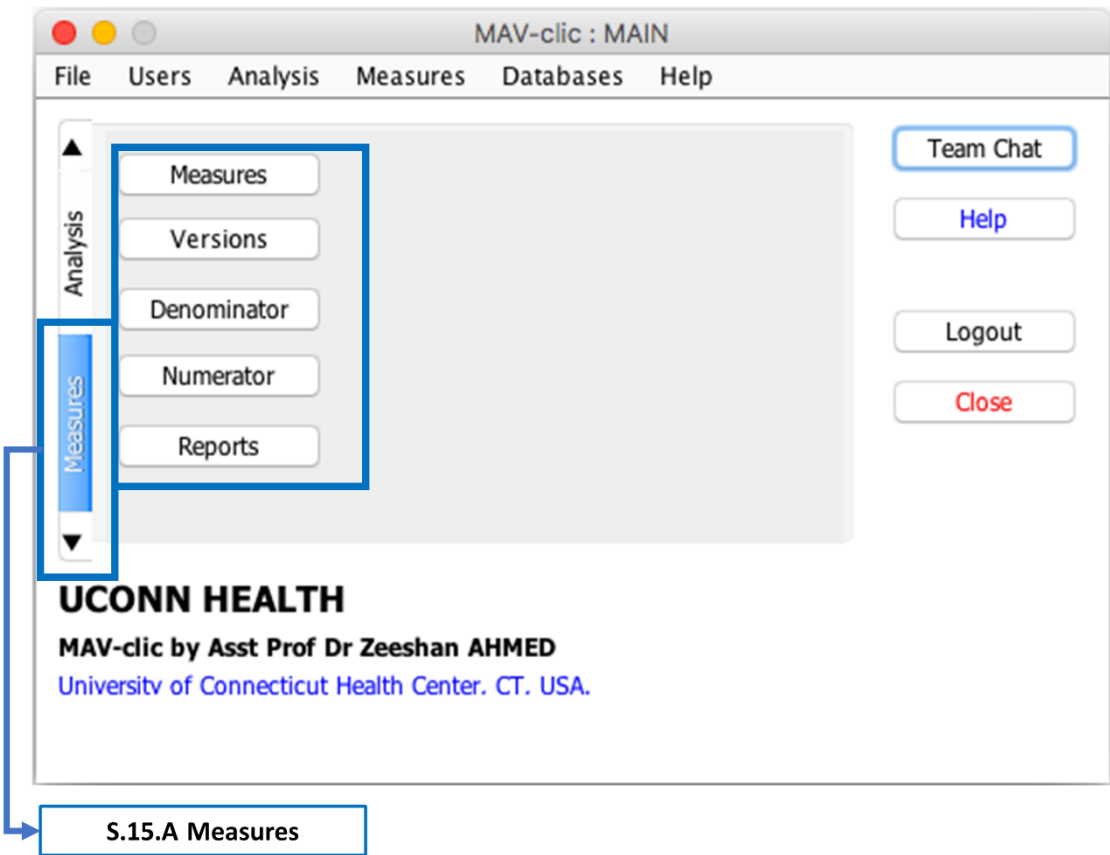
		<ul style="list-style-type: none"> <li>• Individual Chart</li> <li>• Dynamic Report: Export the report table information (S.14.A) and combined line graph (S.14.C) to Jasper Report print (.jrprint).</li> <li>• Export CSV: Export the report table information (S.14.A) to Microsoft Excel spreadsheet (.xlsx).</li> <li>• Save Report: Save the report table information (S.14.A) in the “Measures Reports” (S.20.B).</li> </ul>
S.14.C	Line Graphs of Percentages	<p>Displays line graphs having series of percentage data pointes</p> <ul style="list-style-type: none"> <li>• Left Window: Combined chart having all the quality measures in a chronological sequence.</li> <li>• Right Window: Multiple individual chart having a relevant quality measure in a chronological sequence.</li> </ul>

**S.Table.14.** Report Generation in MAV-clic Measurement Analyzer

Once the initial population is built from the Clinical Data Analysis, users can find out the patients who received specific laboratory tests and medications in the Measurement Analysis (S.Figure13). The selected patients in the Clinical Data Analysis and Measurement Analysis are counted and used as denominator, and numerator of quality measures. In Report Generation (S.Figure14), the collected information from the previous two modules can be used to calculate the quality measures, to visualize into the chart, and to make a report.

## Measure Information Management with MAV-clc

Most of quality measures can be represented as the proportion or the percentage which can be calculated with the denominator and the numerator. The denominator counts on the patients treated by healthcare provider during a defined time period. The numerator represent the number of patients who is in the denominator as well as who received the diagnostic lab tests or medications. The Measure tab (in S.Figure15) presents four buttons to choose measure elements. Each button leads users to manage the measure relevant information in terms of measure (S.Figure16), measure version (S.Figure17), denominator (S.Figure18), and numerator (S.Figure19). The calculated information with the denominator and numerator in each measure version is listed in the Measure Report (S.Figure20).



**S.Figure.15.** “Measures” Tab in the MAV-clc

No.	Feature	Description
S.15.A	Measures	<p>In the “Measure” tab, you can set up the measures. Measures consist of five components as follows:</p> <ul style="list-style-type: none"><li>• Measures</li><li>• Versions</li><li>• Denominator</li><li>• Numerator</li><li>• Reports</li></ul>

**S.Table.15.** “Measures” Tab in the MAV-clc

**Measure:**

This is sub-module of Measures. It offers features to collect and maintain information about measures (e.g. name, number, proposed by, year and additional description). The features are presented in S.Figure.16 and explained in S.Table.16.

ID	Name	Number	Proposed By	Year	Description	DateTime
1	Diabetes	CMS122	CMS	2015	HbA1c Poor Control	2017-11-30 11:29:18.0
2	High_Risk_Med	CMS156	CMS	2015	High Risk Med in the EL...	2017-11-30 11:29:2...
3	Sinusitis	PQRS331	CMS	2015	Sinusitis Medication Days	2017-11-30 12:13:0...

**S.Figure.16.** Measure Information in the “Measures” Tab

No.	Feature	Description
S.16.A	Measures information	<p>Create the “Measure” information. Input quality measure name, number, year, and the organization information.</p> <p>Fields:</p> <ul style="list-style-type: none"> <li>Name</li> <li>Number</li> <li>Proposed by</li> <li>Year</li> <li>Description</li> </ul>
S.16.B	Measure Table	Displays the measures’ information.
	Basic Functions	<ul style="list-style-type: none"> <li>Create: To create the new entry.</li> <li>Modify: To modify existing, selected data.</li> <li>Archive: To archive existing, selected data.</li> <li>Export: To export data in Microsoft Excel spreadsheet.</li> <li>Import: To import data from Microsoft Excel spreadsheet.</li> <li>Clear: To clear text fields.</li> <li>Refresh: To refresh and new updates (if exists) data.</li> <li>Search: To search and retrieve the related data to the measure information users entered in a search text field.</li> </ul>

**S.Table.16.** Measure Information in the “Measures” Tab

**Versions:**

This is sub-module of Measures. It offers features to collect and maintain information about the versions of measures. The features are presented in S.Figure.17 and explained in S.Table.17.

**S.17.B Measure Selection Menu**

Measure: 1:Diabetes >

**S.17.C Measure Versions Table**

ID	Name	Version	Number	Description	DateTime	Measure ID
1	A1c_Cont_3	3	CMS122	HbA1c Poor Control	2017-11-30 11:07:...	1
2	A1c_Cont_4	4	CMS122	HbA1c Poor Control	2017-11-30 11:07:...	1
3	A1c_Cont_5	5	CMS122	HbA1c Poor Control	2017-11-30 11:07:...	1
4	Risk_Med_3	3	CMS156	High Risk Med in the ...	2017-11-30 11:26:...	2
5	Risk_Med_4	4	CMS156	High Risk Med in the ...	2017-11-30 11:26:...	2
6	Risk_Med_5	5	CMS156	High Risk Med in the ...	2017-11-30 11:26:...	2
7	Sinusitis_3	3	PQRS331	Sinusitis Medication D...	2017-11-30 12:13:...	3
8	Sinusitis_4	4	PQRS331	Sinusitis Medication D...	2017-11-30 12:13:...	3
9	Sinusitis_5	5	PQRS331	Sinusitis Medication D...	2017-11-30 12:13:...	3

**S.17.A Measures Version Information**

ID: 1  
 Name: A1c\_Cont\_3  
 Version: 3  
 Number: CMS122  
 Description: HbA1c Poor Control  
 DateTime: 2017-11-30 11:07:12.0

Buttons: Modify, Create, Archive, Import, Export, Clear, Refresh

Total Measures: 9

Search:  Search

☐ Show archived data as well.

Proprietary, designed and developed by Asst. Prof. Dr. Zeehan AHMED at the University of Connecticut Health Center (UConn Health), USA.

**S.Figure.17.** Measure Version Information in the “Measures” Tab

No.	Feature	Description
S.17.A	Measure Version information	Create the “Measure version” of the quality measures in the “Measures”. Fields: <ul style="list-style-type: none"> <li>Name</li> <li>Version</li> <li>Number</li> <li>Description</li> </ul>
S.17.B	Measure Selection Men	Once the “Measures” information is created, users can select the one of measures using drop down menu. Enter the submit button “>” next to the “Measures” drop down menu to see the sorted result in the measure version table (S.17.C).
S.17.C	Measure Version Table	Displays the measures’ information.
	Table Basic Functions	<ul style="list-style-type: none"> <li>Create: To create the new entry.</li> <li>Modify: To modify existing, selected data.</li> <li>Archive: To archive existing, selected data.</li> <li>Export: To export data in Microsoft Excel spreadsheet.</li> <li>Import: To import data in Microsoft Excel spreadsheet.</li> <li>Clear: To clear text fields.</li> <li>Refresh: To refresh and new updates (if exists) data.</li> <li>Search: To search and retrieve the related data to the measure information users entered in a search text field.</li> </ul>

**S.Table.17.** Measure Version Information in the “Measures” Tab

**Measure Versions Denominator:**

This is sub-module of Measures. It offers features to collect and maintain information about Measure Version Denominator. The features are presented in S.Figure.18 and explained in S.Table.18.

**S.18.B Measure Version Selection Menu**

Measure Ver. 1:A1c\_Cont\_3 >

ID 1

Denominator Dig\_Dia

Description Diagnosis\_Diabetes

DateTime 2017-11-30 11:10:37.0

Modify Create

Archive

Import Export

Clear Refresh

Total Denominator: 24

**S.18.C Measure Version Denominator Table**

ID	Denominator	Description	DateTime	Measure Version ID
1	Dig_Dia	Diagnosis_Diabetes	2017-11-30 11:10:37.0	1
2	Age>17	Age>17 years	2017-11-30 11:12:18.0	1
3	Age<75	Age<75 years	2017-11-30 11:32:34.0	1
4	Enc	Encounter	2017-11-30 11:12:59.0	1
5	Dig_Dia	Diagnosis_Diabetes	2017-11-30 11:13:37.0	2
6	Age>17	Age>17 years	2017-11-30 11:32:09.0	2
7	Age<75	Age<75 years	2017-11-30 11:32:26.0	2
8	Enc	Encounter	2017-11-30 11:14:00.0	2
9	Dig_Dia	Diagnosis_Diabetes	2017-11-30 11:14:15.0	3
10	Age>17	Age>17 years	2017-11-30 11:14:29.0	3
11	Age<75	Age<75 years	2017-11-30 11:32:42.0	3
12	Enc	Encounter	2017-11-30 11:14:53.0	3
13	Age>65	Age>65 years	2017-11-30 11:16:52.0	4
14	Enc	Encounter	2017-11-30 11:17:11.0	4
15	Age>65	Age>65 years	2017-11-30 11:23:27.0	5
16	Enc	Encounter	2017-11-30 11:24:01.0	5
17	Age>65	Age>65 years	2017-11-30 11:24:19.0	6
18	Enc	Encounter	2017-11-30 11:24:40.0	6
19	Dig_Sin	Diagnosis_Acute_Sinusitis	2017-11-30 12:13:58.0	7
20	Age>17	Age>17 years	2017-11-30 11:33:32.0	7
21	Dig_Sin	Diagnosis_Acute_Sinusitis	2017-11-30 12:14:10.0	8
22	Age>17	Age>17 years	2017-11-30 12:14:16.0	8
23	Dig_Sin	Diagnosis_Acute_Sinusitis	2017-11-30 12:14:27.0	9
24	Age>17	Age>17 years	2017-11-30 12:14:33.0	9

☐ Show archived data as well. Denominator Search

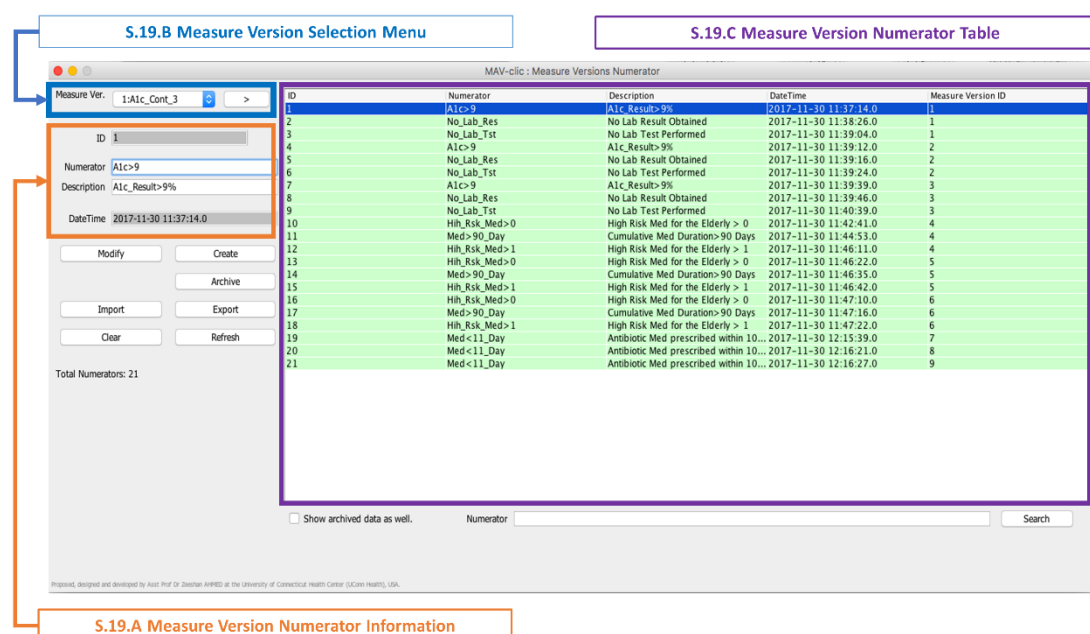
**S.18.A Measure Version Denominator Information**

**S.Figure.18.** Measure Version Denominator in the “Measures” Tab

No.	Feature	Description
S.18.A	Measure Version Denominator information	<p>Create the “Measure Version Denominator” of the quality measures in the “Measure Version”.</p> <p>Fields:</p> <ul style="list-style-type: none"> <li>Denominator</li> <li>Description</li> </ul>
S.18.B	Measure Version Selection Menu	Once the measures & the measure versions information created, users can select the one of the measure versions using drop down menu. Enter the submit button “>” next to the “Measure Version” drop down menu to see the sorted result in the measure version denominator table (S.18.C).
S.18.C	Measure Version Denominator Table	Displays the measures’ denominator information.
	Table Basic Functions	<ul style="list-style-type: none"> <li>Create: To create the new entry.</li> <li>Modify: To modify existing, selected data.</li> <li>Archive: To archive existing, selected data.</li> <li>Export: To export data in Microsoft Excel spreadsheet.</li> <li>Import: To import data from Microsoft Excel spreadsheet.</li> <li>Clear: To clear text fields.</li> <li>Refresh: To refresh and new updates (if exists) data.</li> <li>Search: To search and retrieve the relevant data to the denominator information users entered in a search text field.</li> </ul>

**S.Table.18.** Measure Version Denominator in the “Measures” Tab**Measure Versions Numerator:**

This is sub-module of Measures. It offers features to collect and maintain information about Measure Version Numerator. The features are presented in S.Figure.19 and explained in S.Table.19.

**S.Figure.19.** Measure Version Numerator in the “Measures” Tab

No.	Feature	Description
S.19.A	Measure Version Numerator information	Create the “Measure Version Numerator” of the quality measures in the “Measure Version”. <ul style="list-style-type: none"> <li>Fields:Numerator</li> <li>Description</li> </ul>
S.19.B	Measure Version Selection Menu	Once the measures & the measure versions information created, users can select the one of the measure versions using drop down menu. Enter the submit button “>” next to the “Measure Version” drop down menu to see the sorted result in the measure version numerator table (S.19.C).
S.19.C	Measure Version Numerator Table	Displays the measures’ Numerator information.
	Table Basic Functions	<ul style="list-style-type: none"> <li>Create: To create the new entry.</li> <li>Modify: To modify existing, selected data.</li> <li>Archive: To archive existing, selected data.</li> <li>Export: To export data in Microsoft Excel spreadsheet.</li> <li>Import: To import data in Microsoft Excel spreadsheet.</li> <li>Clear: To clear text fields.</li> <li>Refresh: To refresh and new updates (if exists) data.</li> <li>Search: To search and retrieve the related to the numerator information users enter in a search text field.</li> </ul>



**S.Table.19.** Measure Version Numerator in the “Measures” Tab

## Reports:

This is sub-module of Measures. It offers features to collect and maintain information about created Reports using MAV-clc Measurement Analyzer (S.Figure.14 and S.Table.14). The features are presented in S.Figure.20 and explained in S.Table.20.

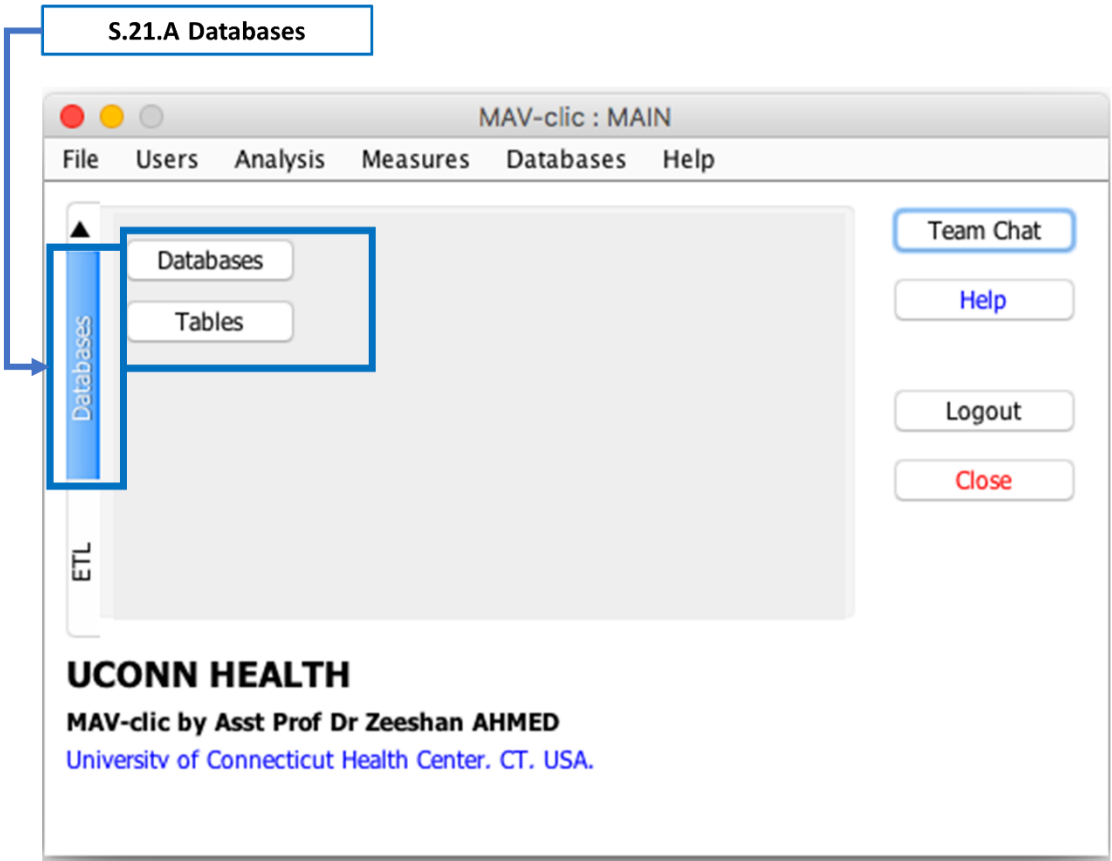
**S.Figure.20.** Measure Reports in the “Measures” Tab

No.	Feature	Description
S.20.A	Measure Report Information	Create “Measure Report” information. Input measure name, numeric values of denominator, numerator, and percentage level.  Fields: <ul style="list-style-type: none"> <li>Number</li> <li>Measure</li> <li>Denominator</li> <li>Numerator</li> <li>Percentage</li> <li>Start Date</li> <li>End Date</li> <li>User</li> </ul>
S.20.B	Measure Report Table	Displays the list of report that is made in the “Measure Report Information” (S.20.A) and “Report Generation” (S.14.B).
	Table Basic Functions	<ul style="list-style-type: none"> <li>Create: To create the new entry.</li> <li>Modify: To modify existing, selected data.</li> <li>Archive: To archive existing, selected data.</li> <li>Export: To export data in Microsoft Excel spreadsheet.</li> <li>Import: To import data in Microsoft Excel spreadsheet.</li> <li>Clear: To clear text fields.</li> <li>Refresh: To refresh and new updates (if exists) data.</li> <li>Search: To search and retrieve the related data to the report information users enter in a search text field.</li> </ul>

**S.Table.20.** Measure Reports in the “Measures” Tab

## Database Management with MAV-clc

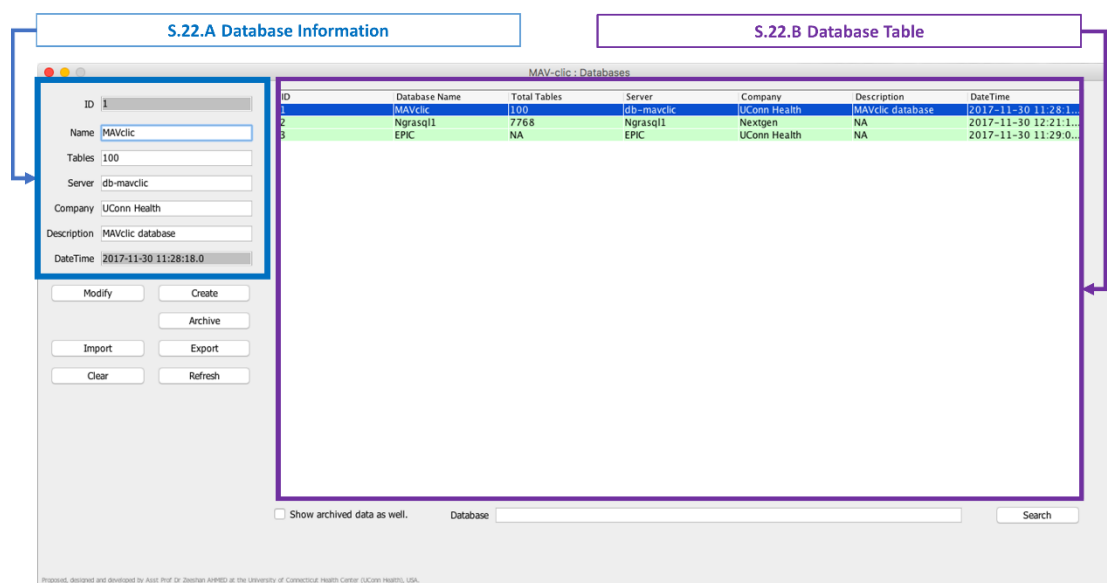
A table is collection of EHR data in a structured format in a database. Similar to the general database system, a given table can only belong to a single database, and the collected tables can be one database. Based on the structure, Database tab allows users to navigate, create, modify and archive databases and tables at the S.Figure.22 and S.Figure23. It presents the way to manage and interact with databases and tables.



**S.Figure.21.** “Databases” Tab in the MAV-clc

No.	Feature	Description
S.21.A	Databases	In the “Databases” tab, users can set up the databases, tables.

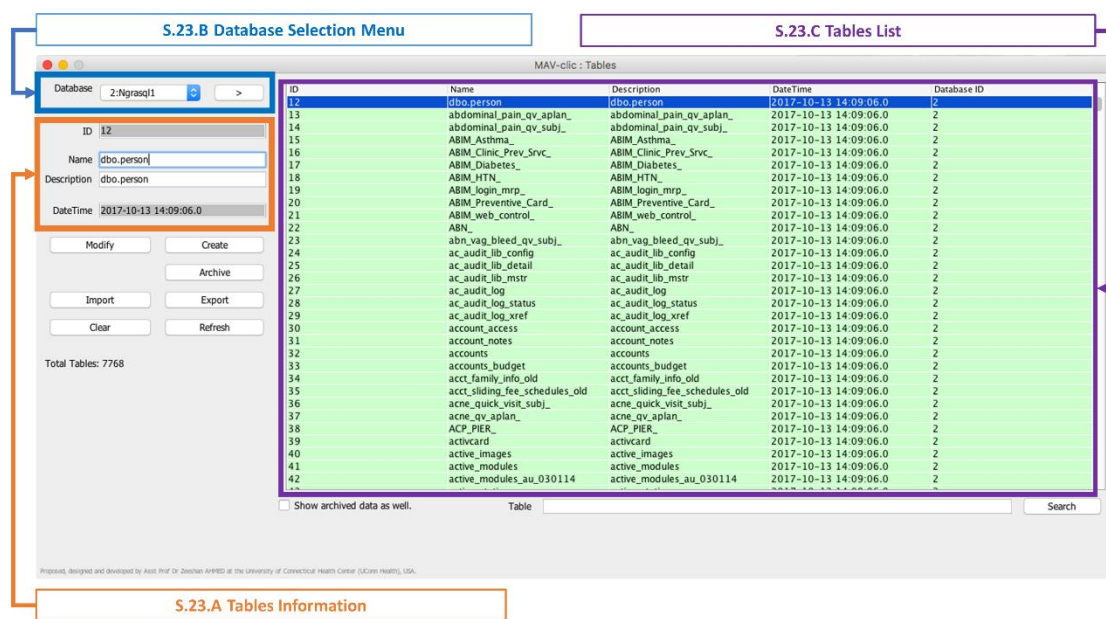
**S.Table.21.** “Databases” Tab in the MAV-clc



**S.Figure.22.** Database Information in the “Databases” Tab

No.	Feature	Description
S.22.A	Database Information	<p>Create “Databases” information. Input database name, number of tables, server name.</p> <p>Fields:</p> <ul style="list-style-type: none"> <li>• Number</li> <li>• Tables</li> <li>• Server</li> <li>• Company</li> <li>• Description</li> </ul>
S.22.B	Database Table	Displays the database information
	Table Basic Functions	<ul style="list-style-type: none"> <li>• Create: To create the new entry.</li> <li>• Modify: To modify existing, selected data.</li> <li>• Archive: To archive existing, selected data.</li> <li>• Export: To export data in Microsoft Excel spreadsheet.</li> <li>• Import: To import data in Microsoft Excel spreadsheet.</li> <li>• Clear: To clear text fields.</li> <li>• Refresh: To refresh and new updates (if exists) data.</li> <li>• Search: To search and retrieve the related data to the database information users entered in a search text field.</li> </ul>

**S.Table.22.** Database Information in the “Databases” Tab



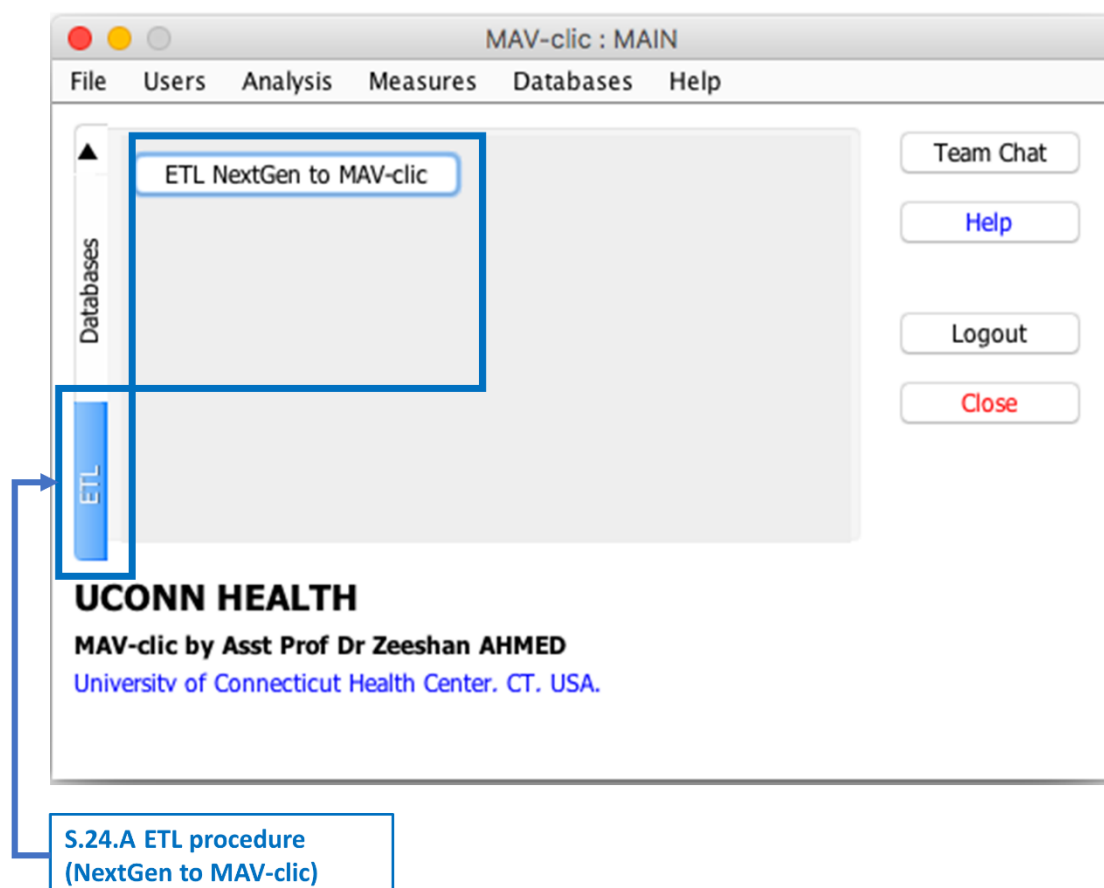
**S. Figure.23.** Table Information in the “Databases” Tab

No.	Feature	Description
S.23.A	Tables Information	<p>Create the “Tables” information.</p> <p>Fields:</p> <ul style="list-style-type: none"> <li>Name</li> <li>Description</li> </ul>
S.23.B	Database Selection Menu	<ul style="list-style-type: none"> <li>Once the database information created, users can select the one of database using drop down menu.</li> <li>Enter the submit button “&gt;” next to the “Database” drop down menu to see the filtered result in the table (S.23.C).</li> </ul>
S.23.C	Tables List	Displays the “Tables” information in the Database.
	Table Basic Functions	<ul style="list-style-type: none"> <li>Create: To create the new entry.</li> <li>Modify: To modify existing, selected data.</li> <li>Archive: To archive existing, selected data.</li> <li>Export: To export data in Microsoft Excel spreadsheet.</li> <li>Import: To import data in Microsoft Excel spreadsheet.</li> <li>Clear: To clear text fields.</li> <li>Refresh: To refresh and new updates (if exists) data.</li> <li>Search: To search and retrieve the related data to the table information users entered in a search text field.</li> </ul>

**S. Table.23.** Table Information in the “Databases” Tab

## ETL Management with MAV-clic

EHR data collect enormous of data. EHR covers all the medical data which is collected during an inpatient hospitalization, an outpatient clinic visit, an emergency room visit etc. Each visit can produce dozens of tables along with diagnosis, medication, laboratory results, imaging results, payment information etc. Integration with entire EHR data in the system that focuses on analyzing clinical data is not cost effective in terms of money and time.



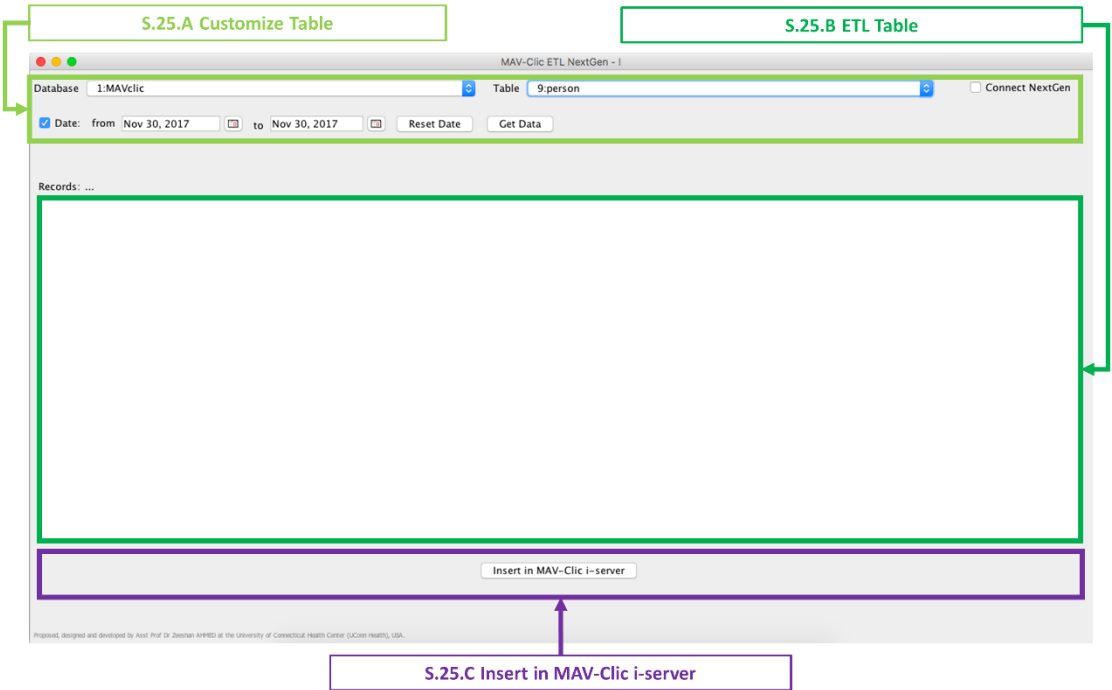
S.24.A ETL procedure  
(NextGen to MAV-clic)

**S.Figure.24.** “ETL” Tab in the MAV-clic

No.	Feature	Description
S.24.A	ETL Procedure (NextGen to MAV-clic)	In “ETL” tab, users can move the table in NextGen database to MAV-clic <i>i</i> -server.

**S.Table.24.** “ETL” Tab in the MAV-clic

Therefore, it is important to determine the clinical data of interest and to proceed the extraction, transformation, and loading (ETL) functions in order to save the data in the MAV-clic *i*-server. S.Figure25 presents the way to define the database, table and to move the selected table to the MAV-clic *i* server with the ETL procedures. The loaded table to the MAV-clic *i*-server can be used to evaluate the clinical research and quality measures.



**S.Figure.25.** MAV-clc ETL Procedure: NextGen to MAV-clc *i*-server

No.	Feature	Description
S.25.A	Customize Table	Find a table user want to extract by selecting the following options. <ul style="list-style-type: none"><li>• Database: Select one of databases using drop-down menu.</li><li>• Table: Select one of tables using drop-down menu.</li><li>• Connect NextGen: Check the option to connect the NextGen (EHR) database.</li><li>• Date: Customize the range of date.</li><li>• Reset Date: Reset the options.</li><li>• Get Data: Run the system.</li></ul>
S.25.B	ETL Table	Displays the table information.
S.25.C	Insert in MAV-clc i-server	Enter this button to upload the ETL table (S.25.B) to the MAV-clc <i>i</i> -server.

**S.Table.25.** MAV-clc ETL Procedure: NextGen to MAV-clc *i*-server

## Installation and Configuration

MAV-clic is programmed in Java programming language, built and tested at both Mac-OS-X and Windows platform. To successfully run (JAR file), it requires Java Version 8 with Update 131 (build 1.8.0\_131-b11) can be downloaded from [www.java.com](http://www.java.com). Additional information and updates are available at: <https://github.com/drzeeshanahmed/MAV-clic/wiki>. For further assistance, it is advised to contact MK and ZA.

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## Authors and contributions

Dr Ahmed perceived the idea and did all work on the software and infrastructure design and implementation and related aspects of MAV-clic. Dr Ahmed and Dr Kim did analysis and performance evaluation of MAV-clic. Dr Liang guided study.

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**Bruce T. Liang, M.D., F.A.C.C.**, is the Dean, UConn School of Medicine, University of Connecticut Health Center. Dr. Liang is the Director, Pat and Jim Calhoun Cardiology Center, and Ray Neag Distinguished Professor of Cardiovascular Biology and Medicine. Dr. Liang is a the fellow of the American College of Cardiology, the American Heart Association and the Council on Clinical Cardiology and Basic Cardiovascular Sciences. He is also a member of the American Society for Clinical Investigation.

