

QcDM Project User Guide

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1. Overview and Installation

The QcDM (Quality care for Diabetes Mellitus) Project provides R-Shiny applications for generating glucometrics measures from point-of-care blood glucose data at three different units of analysis: patient-sample, patient-day, and patient-stay. The application facilitates convenient and flexible generation of glucometrics measures by providing user-friendly graphical user interfaces (GUIs) that runs in a browser on the user's desktop.

The QcDM Project consists of two R-Shiny GUIs and an R package. The first GUI, QcDMconverter, processes raw glucose data files to conform to the data format required by the application. The second GUI, QcDMui, is the main tool of the QcDM Project that uses functions in the [QcDM package](https://github.com/nyilin/QcDM) (<https://github.com/nyilin/QcDM>) to analyse processed glucose data to generate glucometrics measures.

The application operates on Windows and Mac operating systems. The current version of this application can be downloaded from a [GitHub repository](https://github.com/nyilin/QcDM_Project) (https://github.com/nyilin/QcDM_Project). Installation of this application is described in details in the following sections.

1.1. Install R and RStudio

The QcDM Project runs on R version 3.6.0 or later, but users should avoid version 4.0.0 because it has been reported to have issues with Shiny applications. Users are recommended to install the latest version of R and RStudio by following the instructions below.

Install R from the installer downloadable from the official website of the R Project.

- For Windows: download the Setup Wizard from <https://cran.r-project.org/bin/windows/base/>. Follow through the installation steps and keep the default options.
- For macOS: download the installer (a pkg file) from <https://cran.r-project.org/bin/macosx/>. Follow through the installation steps and keep the default options.

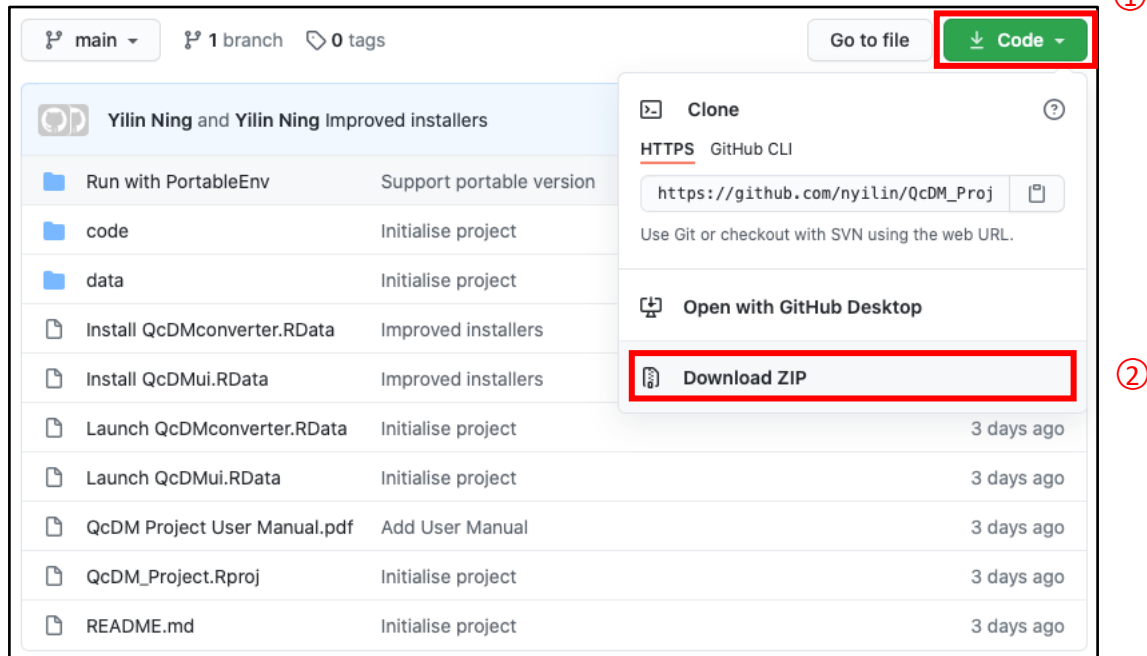
Install RStudio Desktop from the installer downloadable from the official website, <https://rstudio.com/products/rstudio/download/#download>.

For macOS, an additional application, XQuartz, is required, which can be downloaded from the official website: <https://www.xquartz.org>.

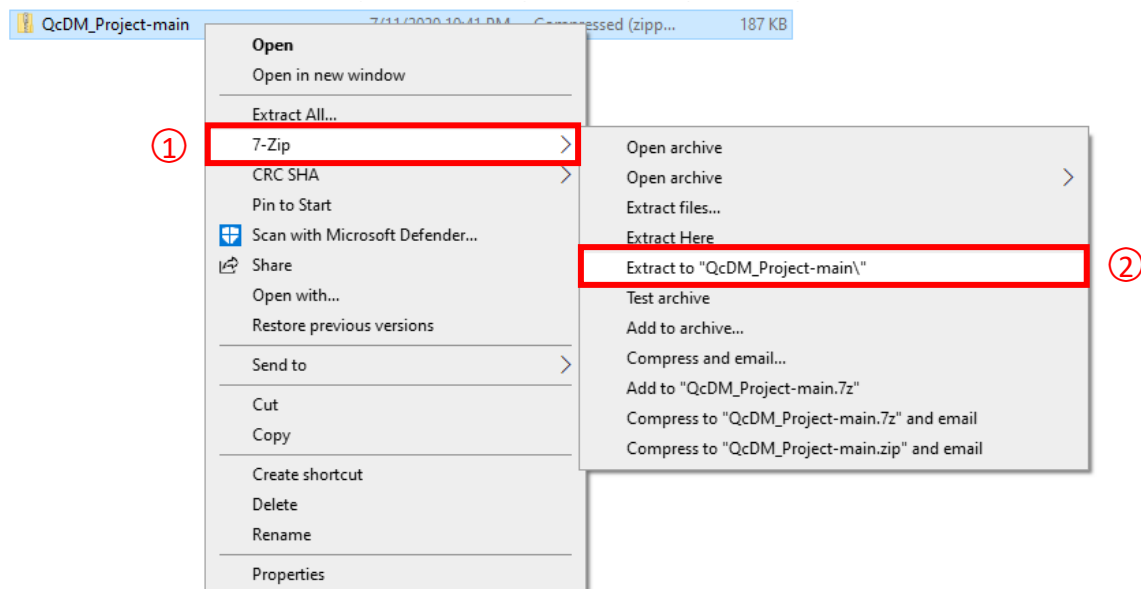
1.2. Download QcDM Project

From the [GitHub repository for the QcDM Project](https://github.com/nyilin/QcDM_Project)

(https://github.com/nyilin/QcDM_Project), download the project as a zip file, named 'QcDM_Project-main.zip'. **We recommend using Chrome to access the link and download the zip file:**



For Windows, unzip the file by right-clicking on 'QcDM_Project-main.zip' and selecting the following (and for illustration purposes we assume 7-Zip is used but any software that unzips file can be used):



For macOS, unzip the file by doubling clicking on it.

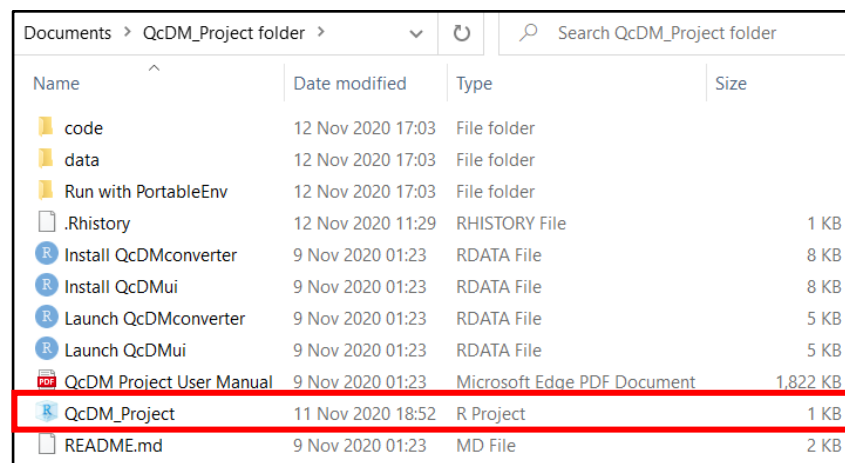
We recommend users to rename the folder as 'QcDM_Project folder' and move this folder to the 'Documents' folder. In the rest of this document, we assume users have followed the recommendations to rename and move the QcDM Project folder and use screenshots

from the Windows operating system, but these instructions are also applicable to macOS users.

1.3. Install required R packages

A few R packages are required to use the two GUIs in the QcDM Project, and they can be installed by using the RData files in the 'QcDM_Project folder' following the instructions below.

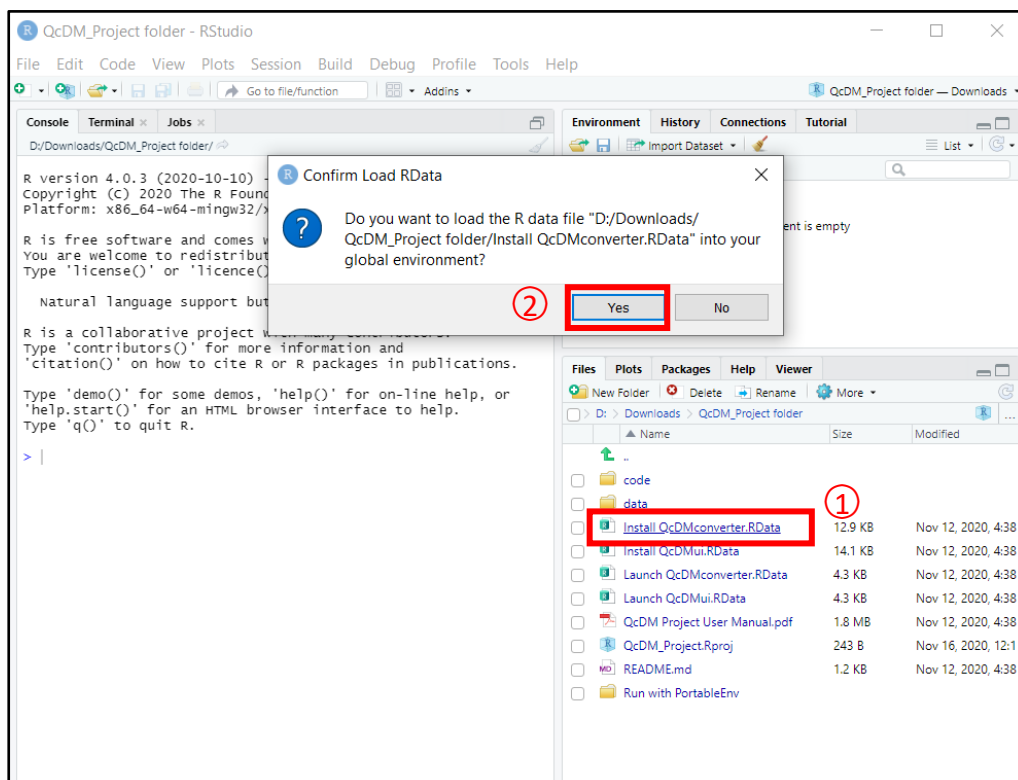
The screenshot below shows all the subfolders and files contained in the 'QcDM_Project folder'. Firstly, users need to open RStudio by doubling-clicking 'QcDM_Project.Rproj' in the 'QcDM_Project folder':



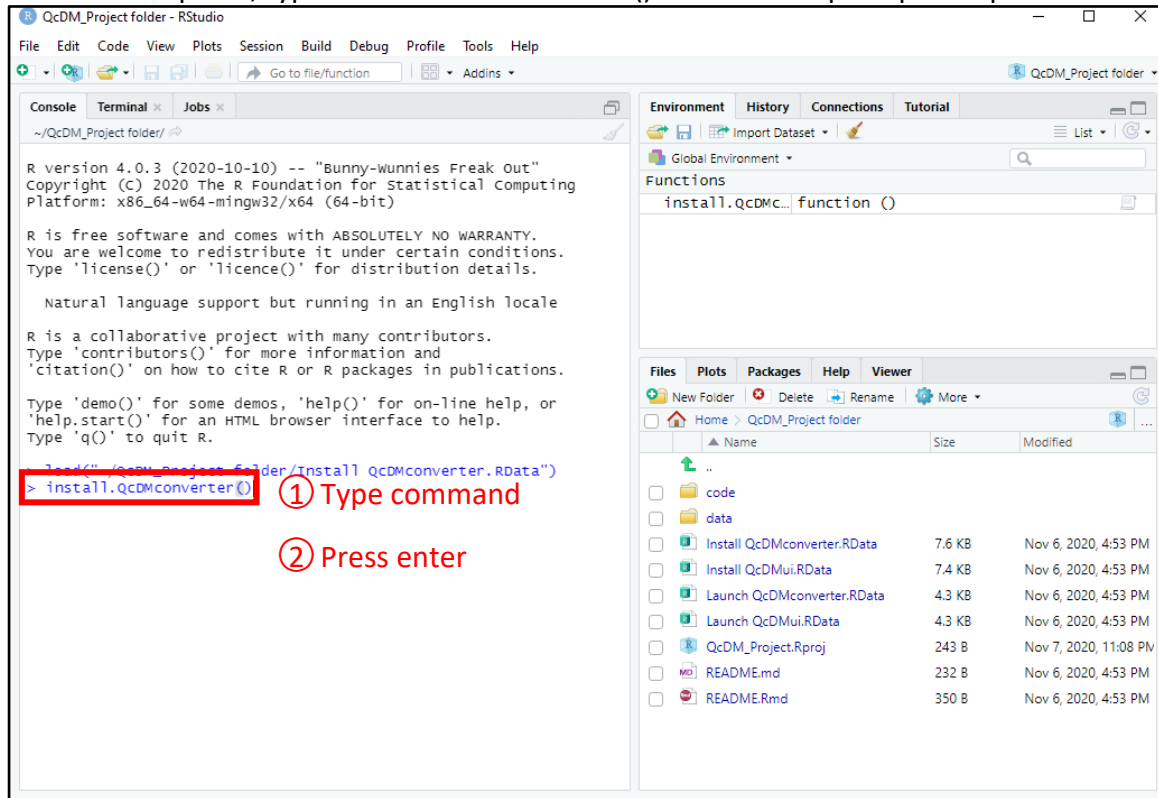
Name	Date modified	Type	Size
code	12 Nov 2020 17:03	File folder	
data	12 Nov 2020 17:03	File folder	
Run with PortableEnv	12 Nov 2020 17:03	File folder	
.Rhistory	12 Nov 2020 11:29	RHISTORY File	1 KB
Install QcDMconverter	9 Nov 2020 01:23	RDATA File	8 KB
Install QcDMui	9 Nov 2020 01:23	RDATA File	8 KB
Launch QcDMconverter	9 Nov 2020 01:23	RDATA File	5 KB
Launch QcDMui	9 Nov 2020 01:23	RDATA File	5 KB
QcDM Project User Manual	9 Nov 2020 01:23	Microsoft Edge PDF Document	1,822 KB
QcDM_Project	11 Nov 2020 18:52	R Project	1 KB
README.md	9 Nov 2020 01:23	MD File	2 KB

1.3.1. Install QcDMconverter

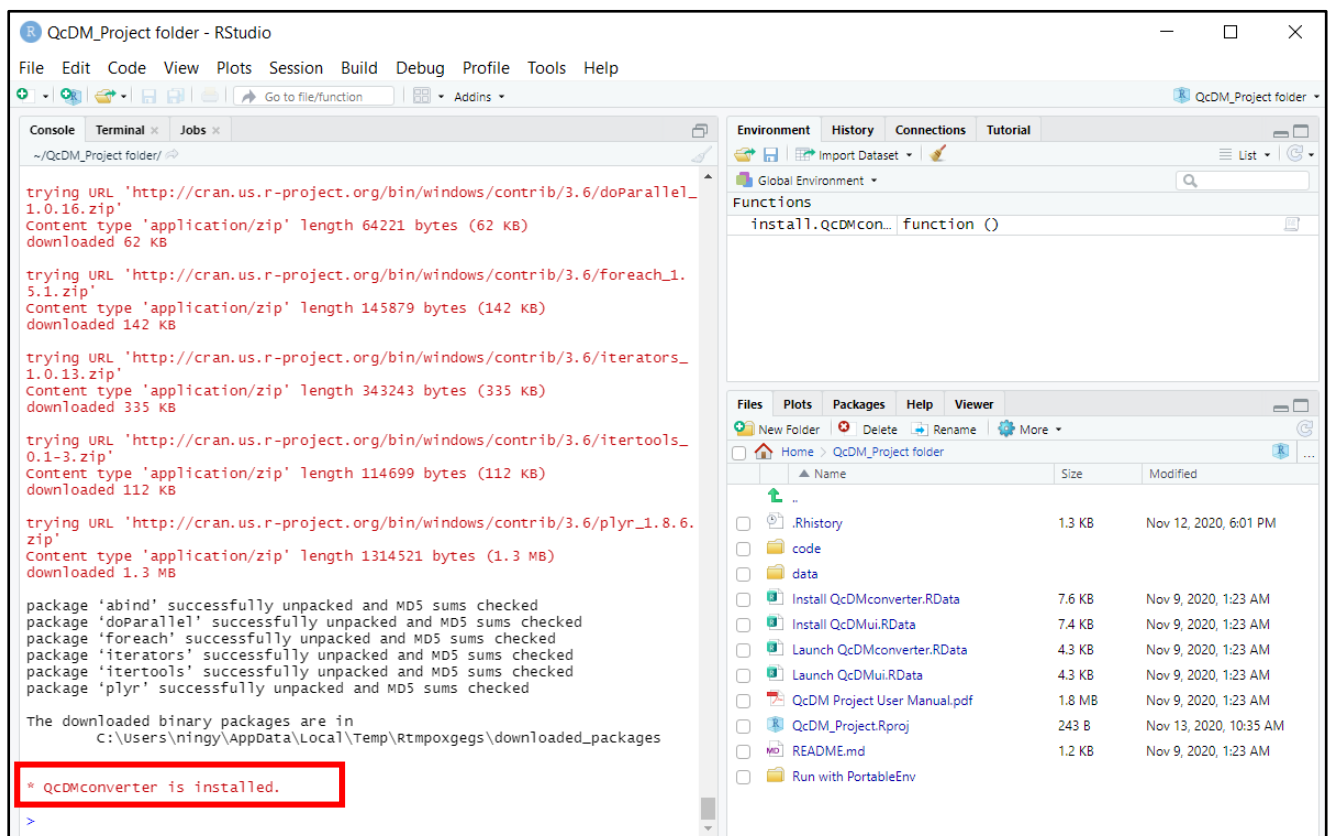
In the File panel of RStudio, click 'Install QcDMconverter.RData', and click 'Yes' in the pop-up window.



In the Console panel, type 'install.QcDMconverter()' after the '>' prompt and press Enter.



Installation is successful when a message '* QcDMconverter is installed' is displayed in the Console panel (please ignore 'warning message' if any). Do not close the RStudio window as it will be used to install another R package (QcDMui).



1.3.2. Install QcDMui

Similar to the steps in the previous section, click on 'Install QcDMui.RData' in the File panel and click 'Yes' in the pop-up window.

In the Console panel, type 'install.QcDMui()' after the '>' prompt and press Enter.

Installation is successful when a message '* QcDMui is installed' is displayed in the Console panel.

Close the RStudio window after successfully installing QcDMconverter and QcDMui. If prompted to select whether to save workspace image or history when closing the window, there is no need to save either of them.

2. User guide for QcDMconverter

QcDMconverter is an R-Shiny application that processes raw input glucose data based on the requirements of the QcDMui to simplify the analytical steps when generating glucometrics measurements.

The following information is required from an input glucose data file for the generation of glucometrics:

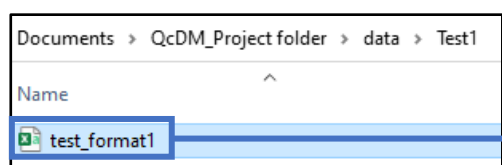
- an indicator for hospital stays experienced by each patient,
- the date-time (or date) stamp associated with each glucose measurement (and see Section 2.2 for an example of date stamp),
- the value of each glucose measurement,
- the ward location associated with each glucose measurement.

As different blood glucose measuring system may generate glucose data in different units (i.e., mmol/L or mg/dL), users are required to specify the unit of glucose readings when importing them into QcDMconverter. QcDMconverter will store glucose data measured in different units in different folders to facilitate the generation of glucometrics in subsequent steps (see Section 2.1 and 2.2 for detail).

New input glucose data may be provided as a single comma-separated version (CSV) file (e.g., see Test1 described in Section 2.1), or as multiple CSV files that follow the same format (e.g., see Test2 described in Section 2.2). QcDMconverter extracts essential information from input file(s) and converts them to a common format that conforms to the requirements by QcDMui.

2.1. Test1: Processing a single input file using QcDMconverter

To illustrate the use of QcDMconverter, we simulated glucose data with 5594 rows for 100 unique hospital stays in July 2020, randomly assigned into 4 ward locations (i.e., A, B, C and D). The unit of measurement of the glucose readings is mmol/L. For illustrative purposes, 3 of the 5594 rows had non-numerical glucose readings. This data, which conforms to the required data format by QcDMui (described in detail in Section 3.1), is saved as a CSV file named 'test_format1.csv' in the 'Test1' folder, which is in the 'data' subfolder of 'QcDM_Project folder'.

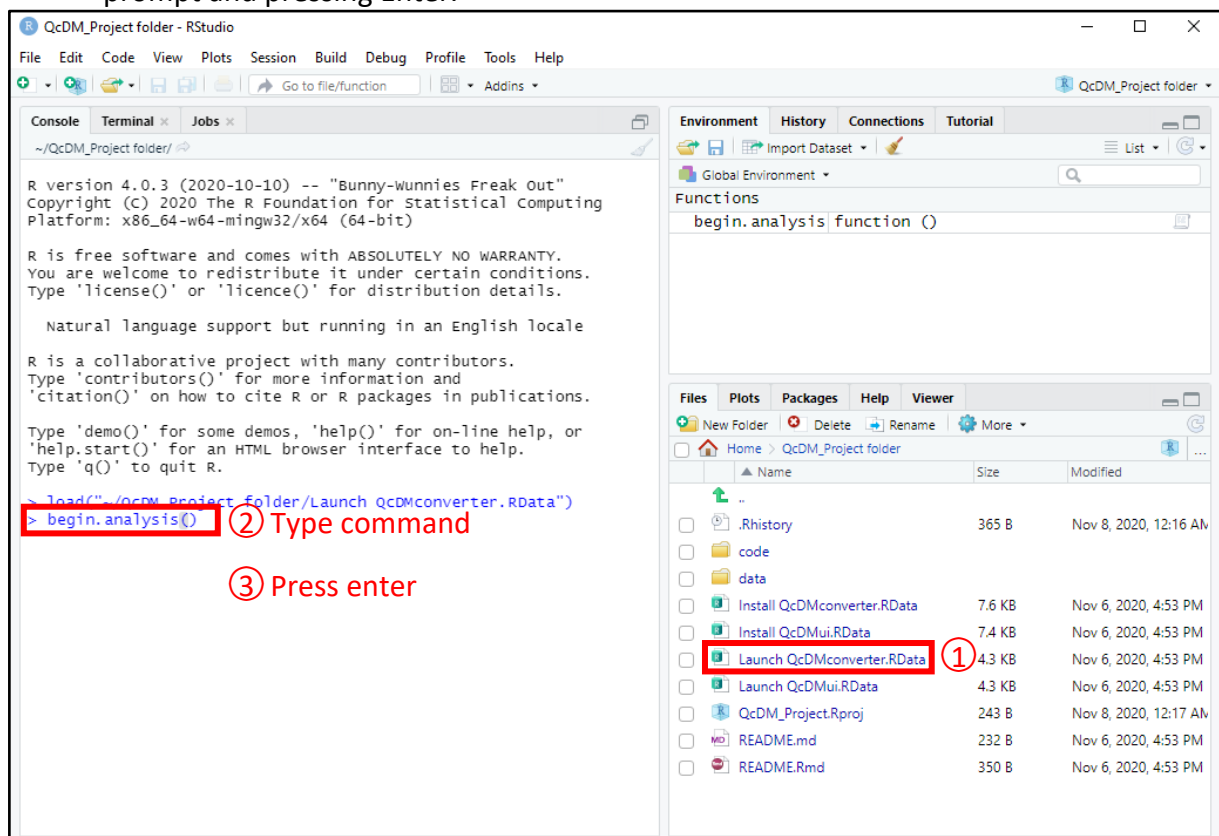


	A	B	C	D
1	ADMISSION.ID	RESULT	RESULT.DATE	LOCATION
2	1	12.6	7/1/20 3:13	A
3	2	14.1	7/1/20 3:15	B
4	2	8.6	7/1/20 6:43	B
5	1	17.3	7/1/20 11:56	A
6	1	14.1	7/1/20 12:26	A
7	1	10.6	7/1/20 12:37	A
8	2	14.5	7/1/20 13:30	B
9	3	12.5	7/1/20 14:03	C
10	2	11.5	7/1/20 15:33	B

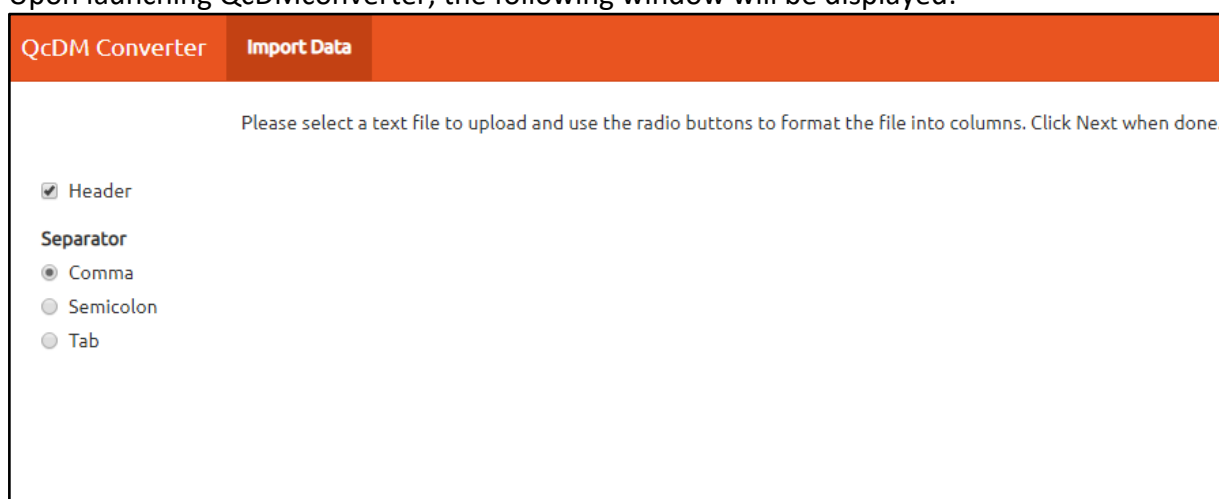
2.1.1. Launch QcDMconverter

To ensure QcDMconverter can be launched properly by using 'Launch QcDMconverter.RData' in the 'QcDM_Project folder', follow the instructions below.

- Goto 'QcDMui_project folder', double click 'QcDM_Project.Rproj' to open RStudio.
- Click 'Launch QcDMconverter.RData' in the File panel, click 'Yes' in the pop-up window.
- In the Console panel, execute command 'begin.analysis()' by typing it after the '>' prompt and pressing Enter.

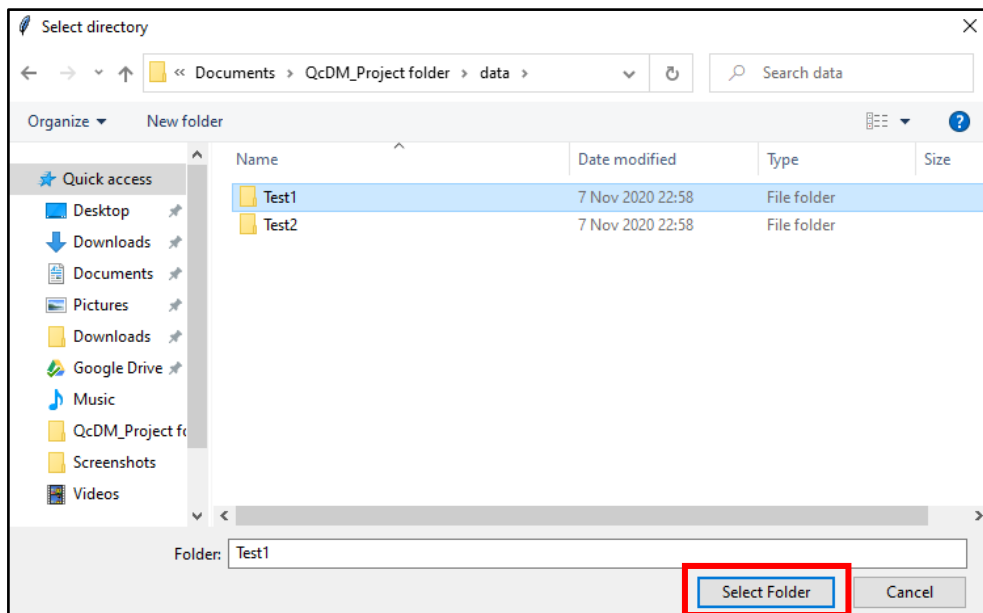


Upon launching QcDMconverter, the following window will be displayed:



2.1.2. Process data

Click on the 'Import Data' tab to begin data processing. The following window will pop out for users to locate the 'Test1' folder:



Click 'Select Folder' to proceed, and the following dashboard will be displayed. Use it to select appropriate options for reading in the input file, and click 'Next' to proceed.

QcDM Converter **Import Data**

Please select a text file to upload and use the radio buttons to format the file into columns. Click Next when done.

Data folder

C:/Users/ningy/Documents/QcDM_Project folder/data/Test1

Select File

test_format1.csv

☒ Header

Separator

☒ Comma

☐ Semicolon

☐ Tab

ADMISSION.ID	RESULT	RESULT.DATE	LOCATION
1	12.6	7/1/20 3:13	A
2	14.1	7/1/20 3:15	B
2	8.6	7/1/20 6:43	B
1	17.3	7/1/20 11:56	A

C:/Users/ningy/Documents/QcDM_Project folder/data/Test1/test_format1.csv

Next

Select appropriate options based the format of the file selected, then click 'Next'

Use the following tab to configuration additional data options based on the input file selected, then click 'Import' to begin data processing. **Note that this will overwrite existing output file that was previously generated from the same input file.**

The screenshot shows the 'Import Data' tab of the QcDM Converter application. On the left, a red box highlights the configuration section with the following options:

- A) Admission ID: dropdown menu with 'ADMISSION.ID' selected.
- B) Result Date: dropdown menu with 'RESULT.DATE' selected.
- B1) Date Format: dropdown menu with 'mdy' selected.
- B2) Time Format: dropdown menu with 'hm' selected.
- C) Result Value: dropdown menu with 'RESULT' selected.
- Unit of Result Value: radio buttons for 'mmol/L' (selected) and 'mg/dL'.
- D) Location: dropdown menu with 'LOCATION' selected.
- An 'Import' button at the bottom.

On the right, a text box contains instructions: 'Please Configure QcDM using the controls on the left and click the 'Import' button. Please monitor the job status using the progress bar below. If an error occurs, click the 'Cancel' button. After clicking 'Import', existing files processed from the same input files will be overwritten.' Below this is a progress bar. At the bottom right, a status box shows a progress bar and the text 'Processing Data Files Processing File: 1 of 1'. A red text box on the right says: 'Configure the GUI based on the format of the file selected, then click 'Import''. Another red text box at the bottom right says: 'After clicking 'Import', a progress bar will be displayed at the lower right corner of the GUI'.

The following text message will be displayed at the top of this tab to indicate the completion of data processing:

```
Single File Processing Mode:

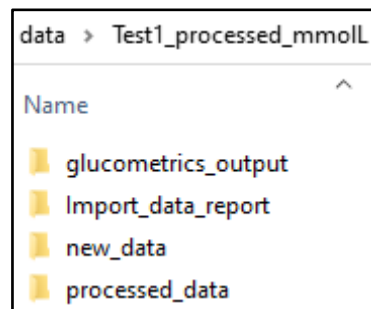
Processing succeeded for the following files:
SUC: C:/Users/ningy/Documents/QcDM_Project folder/data/Test1/test_format1.csv

1 of 1 processed successfully
```

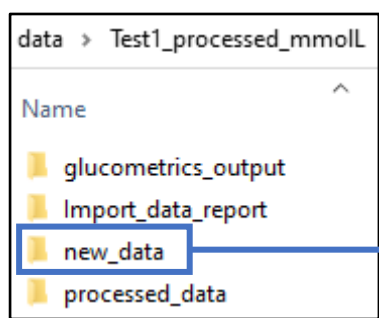
2.1.3. Output from data processing

After performing the data processing steps in Section 2.1.2, a folder named 'Test1_processed_mmolL' is created in the same folder as 'Test1', where 'mmolL' stands for the unit 'mmol/L' used in the input data. Similarly, if the unit 'mg/dL' is used in the example data, the corresponding folder will be named 'Test1_processed_mgdL' instead.

The 'Test1_processed_mmolL' folder contains four subfolders:



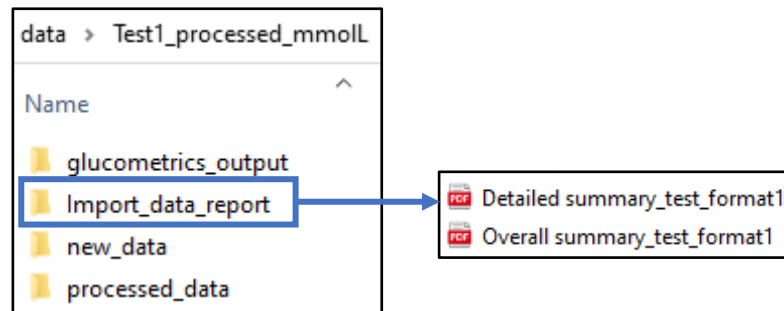
Subfolder 'new_data' contains a file named 'Jul2020_test_format1.csv', which was created from the input 'test_format1.csv', now with the month and year of the glucose data appended to the beginning of its file name, and with the date-time stamp converted to format 'yyyy-mm-dd hh:mm:ss'. As seconds are missing in the date-time stamp in the input data, they are assigned to be '11' by QcDMconverter after data processing.



	A	B	C	D
1	ADMISSION.ID	RESULT.DATE	RESULT	LOCATION
2	1	2020-07-01 03:13:11	12.6	A
3	2	2020-07-01 03:15:11	14.1	B
4	2	2020-07-01 06:43:11	8.6	B
5	1	2020-07-01 11:56:11	17.3	A
6	1	2020-07-01 12:26:11	14.1	A
7	1	2020-07-01 12:37:11	10.6	A
8	2	2020-07-01 13:30:11	14.5	B
9	3	2020-07-01 14:03:11	12.5	C
10	2	2020-07-01 15:33:11	11.5	B

When proceeding to the generation of glucometrics measurements, QcDMui will look for input glucose data in the 'new_data' subfolder (see Section 3). Subfolders 'processed_data' and 'glucometrics_output', which are empty now, will be used later by QcDMui to archive input data and store processed data, respectively.

Subfolder 'Import_data_report' stores PDF reports that will be created by QcDMconverter. There will be two reports per input file, with the names of the corresponding input appended to the end of file names:



'Overall summary_test_format1.pdf' provides basic summary statistics for the input glucose values and date-time stamps to facilitate early detection of data entries errors. For example, the 3 entries in 'test_format1.csv' with non-numerical glucose values are reported:

'test_format1.csv':

	A	B	C	D
1	ADMISSION.ID	RESULT	RESULT.DATE	LOCATION
2		70 d9.6	7/24/2020 13:53	A
3		60 c7.7	7/16/2020 14:04	D
4		47 a4.4	7/26/2020 22:58	B

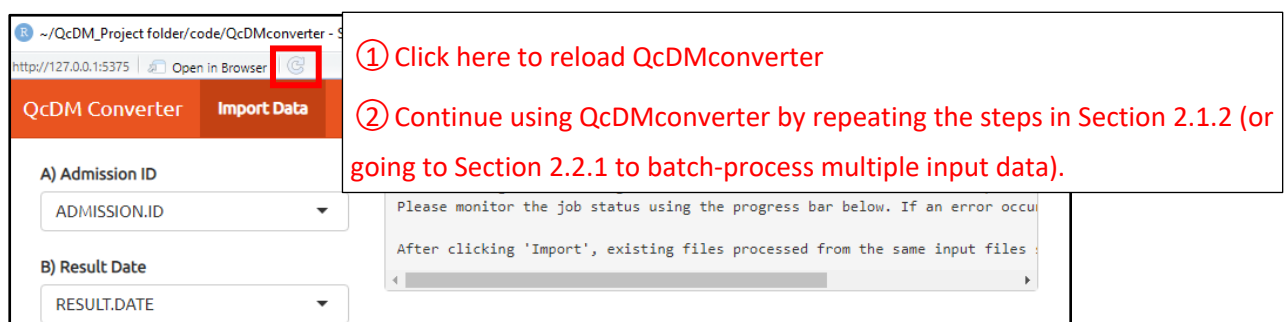
'Overall summary_test_format1.pdf':

2) Report of invalid readings									
Invalid BG values									
	<table> <tr> <th>Label</th><th>N (%)</th></tr> <tr> <td>a4.4</td><td>1 (0.0)</td></tr> <tr> <td>c7.7</td><td>1 (0.0)</td></tr> <tr> <td>d9.6</td><td>1 (0.0)</td></tr> </table>	Label	N (%)	a4.4	1 (0.0)	c7.7	1 (0.0)	d9.6	1 (0.0)
Label	N (%)								
a4.4	1 (0.0)								
c7.7	1 (0.0)								
d9.6	1 (0.0)								
Invalid BG timestamps									
There is no invalid BG timestamp in the input data.									

'Detailed summary_test_format1.pdf' provides more details on the input glucose values and date-time stamps in each ward location.

Invalid glucose values and date-time stamps in the input glucose data will be recoded to 'NA' (which indicates missing data in R) by QcDMconverter in the processed data. If this is inline with users' intention (e.g., the non-numerical glucose values are codes used to indicate entries without glucose measurements and hence should be coded as missing), users may proceed to generate glucometrics from the processed data using QcDMui (see Section 3). If the invalid readings identified in the report reflect errors in data entry, users may want to make the necessary corrections to the raw input data and repeat the steps in Section 2.1.2.

After the completion of data processing for Test1, users may reload QcDMconverter to process other input data:



Users may also close the QcDMconverter window to return to the RStudio window, where they can proceed to the generation of glucometrics measurements using QcDMui (see Section 3), or close the RStudio window now and proceed later. If prompted to select whether to save workspace image when closing the RStudio window, there is no need to save either of them.

2.2. Test2: Processing multiple input files with the same format

QcDMconverter can batch-process multiple files in the folder if they follow the same format. To illustrate this mode of usage, 'test_format1.csv' is split into 4 CSV files and saved to the folder 'Test2' (which is in the 'data' subfolder of 'QcDM_Project folder'), where each file contains all the entries corresponding to the same ward.

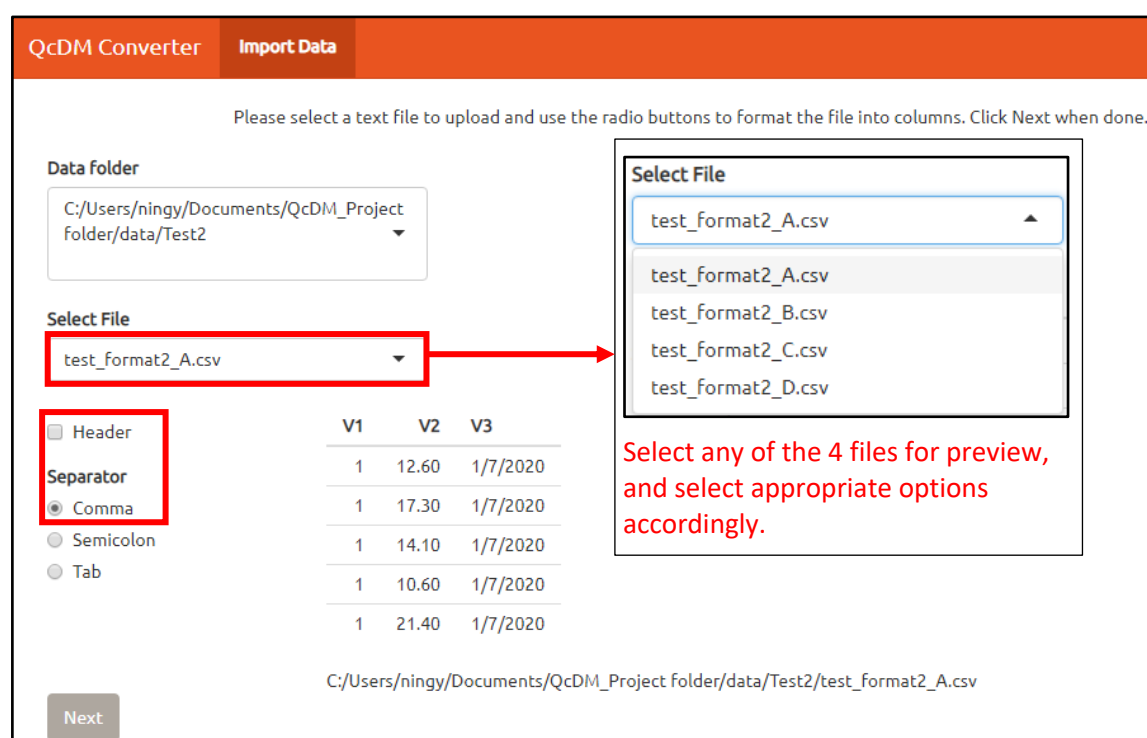
For illustrative purpose, each file now contains three columns, without column names, for the admission ID, glucose values and date stamp for the glucose measurements (without hours or minutes), respectively. Such file format is used in the Yale Glucometrics project when generating glucometrics (1). As the ward location is no longer included as a data column, it must be specified as the last few characters in the file names, preceded by '_ '.



	A	B	C
1	1	12.6	01/07/2020
2	1	17.3	01/07/2020
3	1	14.1	01/07/2020
4	1	10.6	01/07/2020
5	1	21.4	01/07/2020
6	1	7.4	01/07/2020
7	5	9.7	02/07/2020
8	5	11.9	02/07/2020
9	5	5.3	02/07/2020
10	5	12.6	02/07/2020

2.2.1. Process data

After launching the QcDMconverter GUI as described in Section 2.1.1 and selecting the 'Test2' folder using the GUI, users can select any of the 4 files in this folder for preview, in order to inform the specification of options when reading in these files. Make sure you uncheck 'Header'.



QcDM Converter Import Data

Please select a text file to upload and use the radio buttons to format the file into columns. Click Next when done.

Data folder
C:/Users/ningy/Documents/QcDM_Project folder/data/Test2

Select File
test_format2_A.csv

☐ Header

Separator
☒ Comma
☐ Semicolon
☐ Tab

	V1	V2	V3
1	12.60	1/7/2020	
1	17.30	1/7/2020	
1	14.10	1/7/2020	
1	10.60	1/7/2020	
1	21.40	1/7/2020	

Select any of the 4 files for preview, and select appropriate options accordingly.

C:/Users/ningy/Documents/QcDM_Project folder/data/Test2/test_format2_A.csv

Next

After clicking 'Next', the GUI displays an additional option E upon detecting multiple files in the folder selected. Users may choose to process one file each time, or process all files in the folder by selecting 'Yes', provided that all files follow the same format.

QcDM Converter

Import Data

A) Admission ID

V1

B) Result Date

V3

B1) Date Format

dmy

B2) Time Format

Not available

C) Result Value

V2

Unit of Result Value:

☒ mmol/L

☐ mg/dL

Imported files that use different units of result value will be stored in separate folders.

D) Location

<<From Filename>>

E) Process all files in this folder with the configuration above

Yes

Import

Please Configure QcDM using the controls on the left and click the 'Import' button. Please monitor the job status using the progress bar below. If an error occurs, please check the logs.

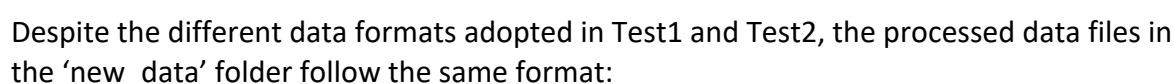
After clicking 'Import', existing files processed from the same input files will be overwritten.

Ward location is now specified as part of the file name instead of as a column in the data.

When the GUI detects multiple files in the selected folder, users have this additional option of batch-processing all files using the same configuration.

After configuration, click 'Import' (under option E) to start processing.

As described in Section 2.1.3, a folder named 'Test2_processed_mmoll' is created by QcDMconverter, with the following four subfolders:



As time stamps are not available in the input data files in Test2, they are assigned as 11:11:11 AM after the data processing.

2) Report of invalid readings

Invalid BG values

Label	N (%)
d9.6	1 (0.1)

Invalid BG timestamps

There is no invalid BG timestamp in the input data.

After the completion of data processing for Test2, users may reload QcDMconverter to process other input data:

The screenshot shows a web browser window displaying the QcDM Converter application. The address bar shows the URL `http://127.0.0.1:5375`. The page has a header with "QcDM Converter" and "Import Data" buttons. Below the header, there are two input sections: "A) Admission ID" with a dropdown menu showing "V1", and "B) Result Date" with a dropdown menu showing "V3". A red box highlights a refresh icon in the browser's address bar. To the right of the browser window, there are two red annotations: "① Click here to reload QcDMconverter." pointing to the refresh icon, and "② Continue using QcDMconverter by repeating the steps in Section 2.1.2 or 2.2.1." Below the browser window, there is a text box with the instruction: "Please monitor the job status using the progress bar below. If an error occurs, After clicking 'Import', existing files processed from the same input files sel".

① Click here to reload QcDMconverter.

② Continue using QcDMconverter by repeating the steps in Section 2.1.2 or 2.2.1.

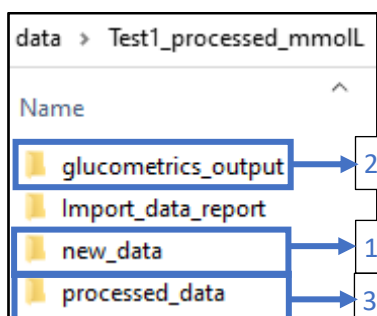
Users may also close the QcDMconverter window to return to the RStudio window, where they can proceed to the generation of glucometrics measurements using QcDMui (see Section 3), or close the RStudio window now and proceed later. If prompted to select whether to save workspace image when closing the RStudio window, there is no need to save either of them.

3. User guide for QcDMui

QcDMui is an R-Shiny graphical user interface developed for convenient and flexible generation of glucometrics measures from point-of-care glucose data.

3.1. Required data format of QcDMui

QcDMui requires a specific data format and folder structure for the input glucose data files. Specifically, QcDMui expects a data folder to have the following subfolders:



2. Processed monthly data will be organized in this subfolder by ward, year and month.

1. User to put glucose CSV file(s) in the format generated by QcDMconverter.

3. After processing, file(s) in 'new_data' will be moved here for archiving purposes.

All glucose data stored in 'new_data' must use the same unit of measurement, i.e., either mmol/L or mg/dL. For easy management, users are recommended to provide glucose data by month, and indicate the calendar time of each file using the first seven characters of the file name, where the first three characters are the abbreviated month, and the next four characters correspond to the four-digit calendar year (e.g., 'Jul2020' for glucose data in July 2020).

As illustrated in the snapshot below, each data file in 'new_data' should contain at least four variables:

	A	B	C	D
1	ADMISSION.ID	RESULT.DATE	RESULT	LOCATION
2	1	2020-07-01 03:13:11	12.6	A
3	2	2020-07-01 03:15:11	14.1	B
4	2	2020-07-01 06:43:11	8.6	B
5	1	2020-07-01 11:56:11	17.3	A
6	1	2020-07-01 12:26:11	14.1	A
7	1	2020-07-01 12:37:11	10.6	A
8	2	2020-07-01 13:30:11	14.5	B
9	3	2020-07-01 14:03:11	12.5	C
10	2	2020-07-01 15:33:11	11.5	B

- ADMISSION.ID: the identifier for a specific hospital stay experienced by a patient.
- RESULT.DATE: the date-time stamp associated with each glucose measurement, where:
 - only '/' or '-' is used to separate date, month and year, and no mix of the two symbols is allowed in a single time variable (see below for an example)
 - ':' is used to separate hour, minute and second, and the order is always 'hh:mm:ss' (see below for an example). Second can be missing, but not minute or hour. This is to allow us to perform distributional analytics for assessing timeliness of glucose measurements (2).
- RESULT: the value of glucose measurement. It can be in mg/dL or mmol/L, but not a mix of the two units. **Users are strongly recommended to indicate the unit in the folder name to avoid confusion.**
- LOCATION: the ward location where the glucose measurements were taken.

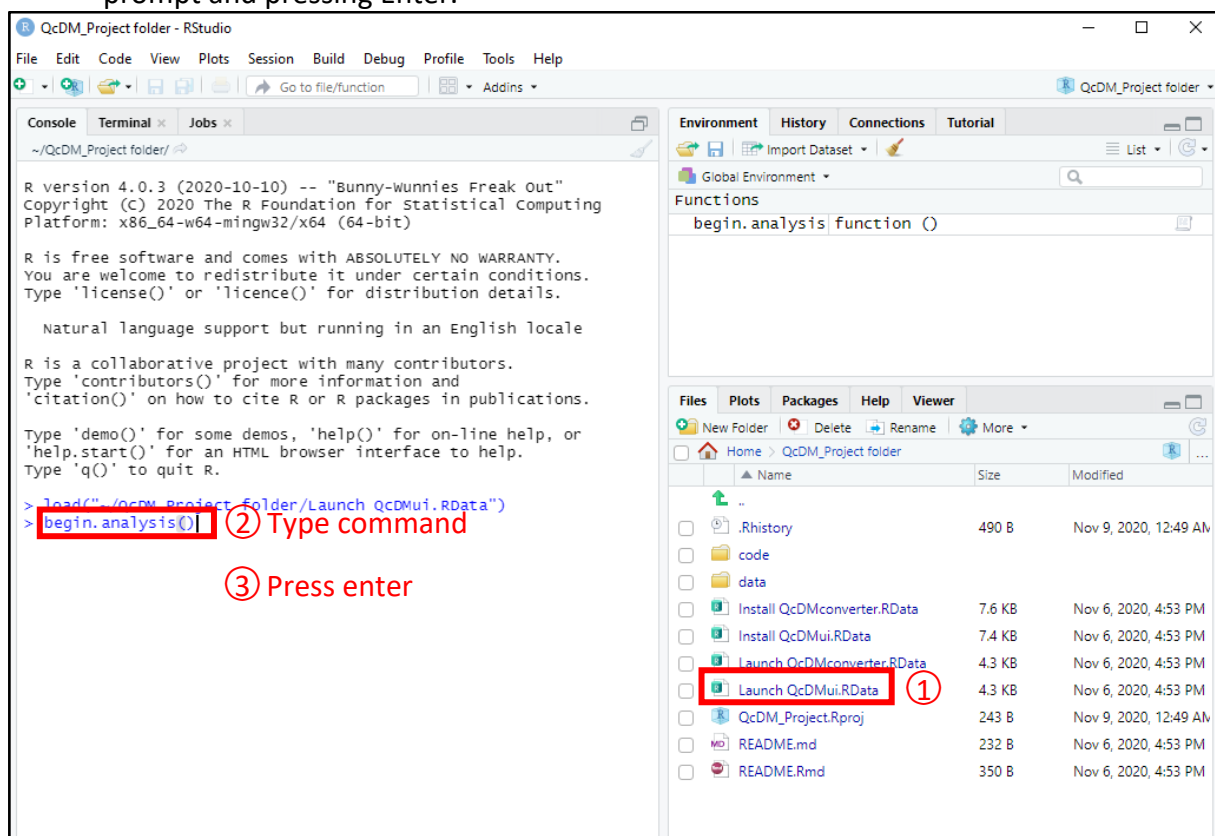
Users are strongly recommended to process raw input data files using QcDMconverter, as described in Section 2, to create the required folder structure and conform to the required data format to facilitate their usage of the QcDMui. In particular, the data processing step using QcDMconverter helps users avoid a mix of units of measurement in the same data folder. Users who choose to manually prepare the data folder are strongly recommended to include the unit of glucose data as part of the folder name (e.g., 'mmol/L' for 'mmol/L' and 'mgdL' for 'mg/dL') to avoid confusion.

The next two sections illustrate the usage of QcDMui and the corresponding output using example data provided in folder 'Test1', which is available in the 'data' subfolder of 'QcDM_Project folder'. We assume users have followed the instructions in Section 2.1 to create a folder 'Test1_processed_mmol/L' that contains the required subfolders and processed data.

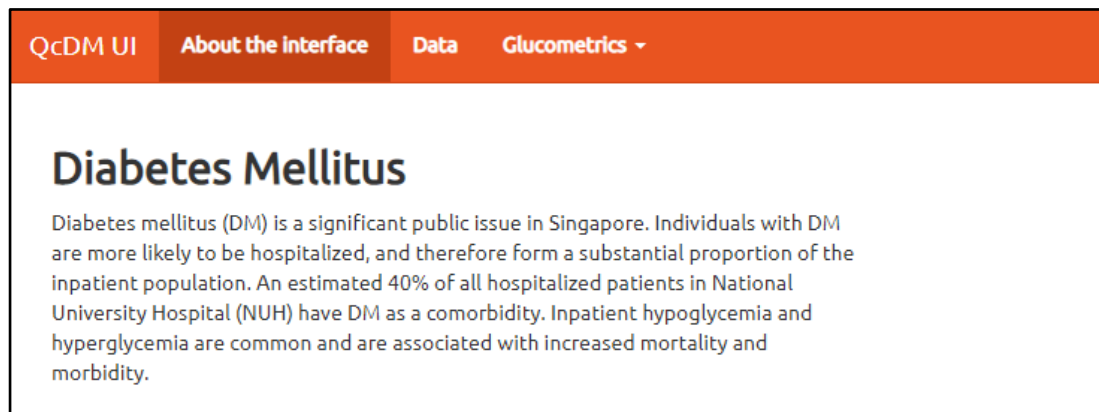
3.2. Launch QcDMui

QcDMui can be launched by using 'Launch QcDMui.RData' in the 'QcDM_Project folder' following the instructions below.

- Goto 'QcDM_Project folder', double click 'QcDM_Project.Rproj' to open RStudio.
- Click 'Launch QcDMui.RData' in the File panel, click 'Yes' in the pop-up window.
- In the Console panel, execute command 'begin.analysis()' by typing it after the '>' prompt and pressing Enter.



Upon launching QcDMui, the following window will be displayed:

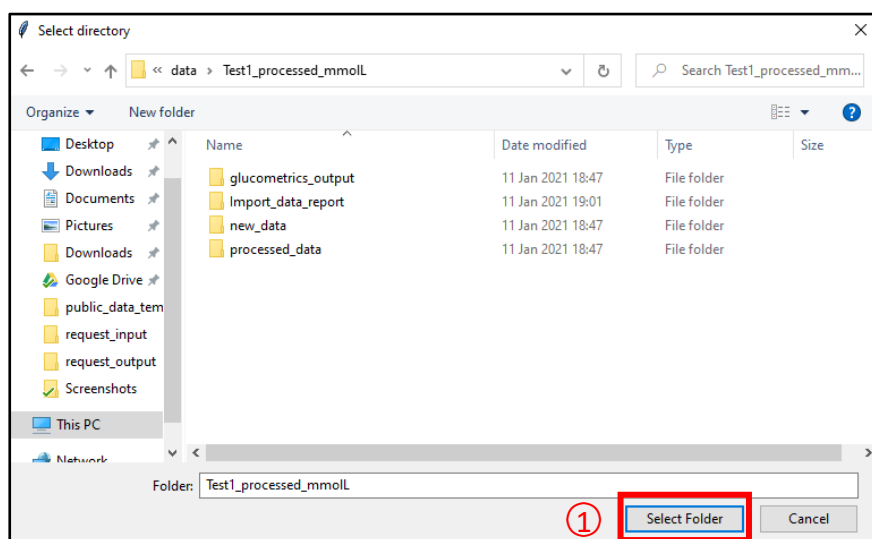


An introduction to the tool and a brief instruction on how to use it is available under the tab 'About the interface'.

3.3. Process data

Users can use the 'Data' tab to specify the glucose data for which glucometrics measurements need to be generated.

The following window will pop out upon clicking on the 'Data' tab for users to locate the 'Test1_processed_mmolL' folder. Click 'Select Folder' to proceed.



After selecting the data folder, specify the unit of glucose data in the selected data folder (i.e., mmol/L) in the GUI, and confirm the selection by clicking 'Confirm data folder and unit of BG readings' in the GUI.

The screenshot shows the 'Data' tab of the QcDM UI. The 'Data folder' is set to 'C:/Users/ningy/Documents/QcDM_Project folder/data/Test1_processed_mmolL'. A red box highlights the instruction: 'After selecting the data folder, please specify the unit of BG readings used in ALL data files within this folder:' with radio buttons for 'mmol/L' (selected) and 'mg/dL'. Below this is a button 'Confirm data folder and unit of BG readings' with a circled '2' next to it. The 'Time range' section shows 'From' and 'To' fields for Year (2021) and Month (1), with a 'Confirm time range' button. The 'Wards' section has radio buttons for 'All wards with data in the selected time range' and 'Selected wards', with 'Confirm choice' and 'Confirm ward' buttons. The 'Exclusion criteria' section has checkboxes for excluding patient stays based on the number of BG measurements or length of stay, with input fields for '2' and '24'. At the bottom, a 'Confirm' button is shown with the text 'Process complete.'

The following two subsections describe the 'Data' tab in detail.

3.3.1. Specify cutoffs and exclusion criteria

QcDM UI **About the interface** **Data** **Glucometrics** ▾

Data folder

C:/Users/ningy/Documents/QcDM_Project Folder/data/Test1_processed_mmol/L

After selecting the data folder, please specify the unit of BG readings used in ALL data files within this folder:

☒ mmol/L
☐ mg/dL

Confirm data folder and unit of BG readings

Hypo cutoff
Please specify the first hypo cutoff (mmol/L): 4
Please specify the second hypo cutoff (mmol/L): 3
Please specify the third hypo cutoff (mmol/L): 2.5

Hyper cutoff
Please specify the first hyper cutoff (mmol/L): 14
Please specify the second hyper cutoff (mmol/L): 20
Please specify the third hyper cutoff (mmol/L): 24

Target range
Please specify the lower value of the target range (mmol/L): 4
Please specify the lower value of the target range (mmol/L): 10

Hyperglycemia index (HGI)
Please specify the cutoff for HGI (mmol/L): 10

Exclusion criteria

☐ Exclude patient stays having fewer BG measurements than the number specified below

2

☐ Exclude patient stays having length of stay less than or equal to the number specified below in terms of hours

24

After selecting the right data folder and parameters, please click on 'Confirm' button below before proceeding to the panel on the right.

Confirm
Process complete.

Users are required to specify the unit of BG readings that is common to ALL data files within the data folder selected.

This part allows users to customize cutoff values for hypoglycemia, hyperglycemia, target range and hyperglycemia index. The first hypo cutoff specified will be used for recurrent hypo in the glucometrics report.

This part allows users to customize exclusion criteria.

Click on 'Confirm' button before proceeding to the panel on the right.

After specifying appropriate cutoff values and exclusion criteria, click on 'Confirm' button. QcDMui will import data in the 'new_data' subfolder, split them by month and ward, and organize the processed data into the respective subfolders within the 'glucometrics_output' subfolder. A text message 'Process complete.' will be displayed under the 'Confirm' button upon completion of data processing. Users can then proceed to the panel on the right to select time period and wards for the generation of glucometrics.

3.3.2. Select time period and wards

Time range:

From

Year

2020

To

Year

2020

Month

7

Month

7

Confirm time range

Wards

☐ All wards with data in the selected time range
☒ Selected wards

Confirm choice

Please select wards to view (multiple selection allowed)

A

Multiple selection allowed

Confirm ward

Number of unique patients in each selected ward and month:

Show

10

 entries

Search:

	Wards	Jul 2020
1	A	29

Showing 1 to 1 of 1 entries

Previous

1

Next

Users are required to use these two parts to specify the period and ward for glucometrics generation, based on the availability of data in the 'glucometrics_output' subfolder.

This is the place where users could customize the exclusion criteria.

After selecting the ward and time range, a summary of the selected data by ward and month will be presented here, so that users can modify their selection if the selected data is not available.

3.4. View glucometrics

After processing glucose data in 'Data' tab, click on 'Glucometrics' tab and then go to 'Summary Statistics' tab to view the following tables that summarize the glucometrics information:

QcDM UI

About the interface

Data

Glucometrics

Data Summary

Summary of BG measurements		Summary
Total (N)		1611
Minimum (mmol/L)		3.2
5-th percentile (mmol/L)		7.7
25-th percentile (mmol/L)		11.1
75-th percentile (mmol/L)		15.8
95-th percentile (mmol/L)		19.5
Maximum (mmol/L)		25.7
Non-numeric values (N)		1

Exclusion Summary

Total number of patient-stays	29
No exclusion criterion was selected.	

Glucometrics

Summary			
Location	A		
Period	01 Jul 2020 to 30 Jul 2020		
	Patient-sample	Patient-day ^{#1}	Patient-stay ^{#2}
Count	1610	316	29
GLYCEMIC CONTROL			
Hyperglycemia			
Percent with glucose ≥ 14 mmol/L	697 (43.3%)	292 (92.4%)	29 (100%)
Percent with glucose ≥ 20 mmol/L	61 (3.8%)	56 (17.7%)	23 (79.3%)
Percent with glucose ≥ 24 mmol/L	5 (0.3%)	5 (1.6%)	4 (13.8%)
Hyperglycemia index (HGI): AUC (> 10 mmol/L)/LOS (in hours)			
	Median (IQR)		3.5 (0.7)
	Mean (SD)		3.6 (0.5)
Other metrics			
Percent with glucose ≥ 4 and < 10 mmol/L	247 (15.3%)	6 (1.9%)	0 (0%)
Mean glucose (mmol/L)			
	Median (IQR)	13.2 (0.4)	13.5 (0.5)
	Mean (SD)	13.5 (0.5)	13.5 (0.5)
Average of mean glucose from patient-days within a patient-stay (mmol/L)			
	Median (IQR)		13.5 (0.4)
	Mean (SD)		13.5 (0.5)
HYPOGLYCEMIA			
Percent with glucose < 4 mmol/L	1 (0.1%)	1 (0.3%)	1 (3.4%)
Percent with glucose < 3 mmol/L	0 (0%)	0 (0%)	0 (0%)
Percent with glucose < 2.5 mmol/L	0 (0%)	0 (0%)	0 (0%)
Percent of patient-stays with a recurrent hypoglycemia (< 4 mmol/L) day			0 (0%)
GLYCEMIC VARIABILITY			
Standard deviation: SD (mmol/L)			
	Median (IQR)	3.2 (1.6)	3.4 (0.5)
	Mean (SD)	3.3 (1.3)	3.5 (0.5)
J-index (mmol/L)			
	Median (IQR)	90.8 (31)	92.6 (10.5)
	Mean (SD)	92.9 (24.2)	92.8 (7.3)

#1: 4 (1.27%) patient-days were removed for calculation of patient-day SD and J-index.

#2: 0 (0%) patient-stays were removed for calculation of patient-stay SD and J-index.

Summary Statistics report is saved in the folder: 'C:/Users/ningy/Documents/QcDM_Project folder/data/Test1_processed_mmolL/Glucometric_report' as a CSV file named 'Test1_processed_mmolL_2021_05_02_12_51_08.csv' and as a HTML report named 'Test1_processed_mmolL_2021_05_02_12_51_08.html'.

Tables above are also saved as a CSV file and a HTML report in the 'Glucometric_report' folder for later use:

Name	Date modified	Type
Test1_processed_mmoll_2021_05_02_12_51_08	2 May 2021 12:51	Microsoft Excel Comma Separated Values File
Test1_processed_mmoll_2021_05_02_12_51_08	2 May 2021 12:51	HTML Document

The HTML report can also be saved as a PDF document by opening it using the Chrome browser:

Glucometrics

Summary statistics
2021-05-02
Data Summary

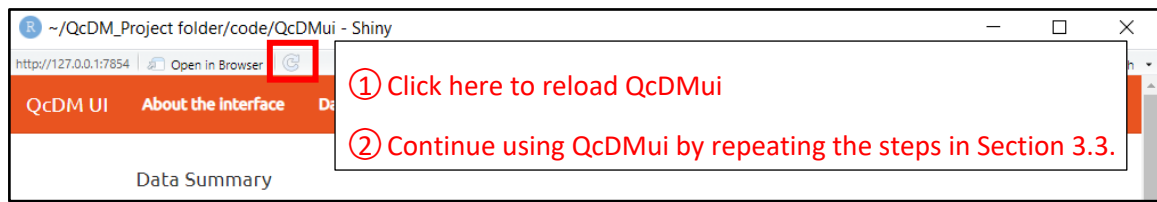
Summary of BG measurements		Summary
Total (N)		1611
Minimum (mmol/L)		3.2
5-th percentile (mmol/L)		7.7
25-th percentile (mmol/L)		11.1
75-th percentile (mmol/L)		11.1
95-th percentile (mmol/L)		11.1
Maximum (mmol/L)		11.1
Non-numerical		0

Exclusion Summary

Glucometrics

Summary	Location	Period	Patient-sample	Patient-day ^{#1}	Patient-stay ^{#2}
Count		01 Jul 2020 to 30 Jul 2020	1610	316	29
GLYCEMIC CONTROL					
Hyperglycemia					
Percent with glucose >= 14 mmol/L			697 (43.3%)	292 (92.4%)	29 (100%)
Percent with glucose >= 20 mmol/L			61 (3.8%)	56 (17.7%)	23 (79.3%)
Percent with glucose >= 24 mmol/L			5 (0.3%)	5 (1.6%)	4 (13.8%)
Hyperglycemia index (HGI): AUC (> 10 mmol/L)/LOS (in hours)					

After viewing glucometrics tables, users may reload QcDMui to process other glucose data:



Users may also close the QcDMui window to return to the RStudio window. When closing the RStudio window, if users are prompted to select whether to save workspace image, there is no need to save either of them.

4. Running QcDM Project from USB Drive

In the previous three sections, we have described how to install and use the QcDM Project on a desktop with a Windows or Mac operating system. Alternatively, the QcDM Project can be installed into a USB Drive and used in a plug-and-play approach on any computer with the **Windows** operating system. This portable approach is not available for the Mac operating system.

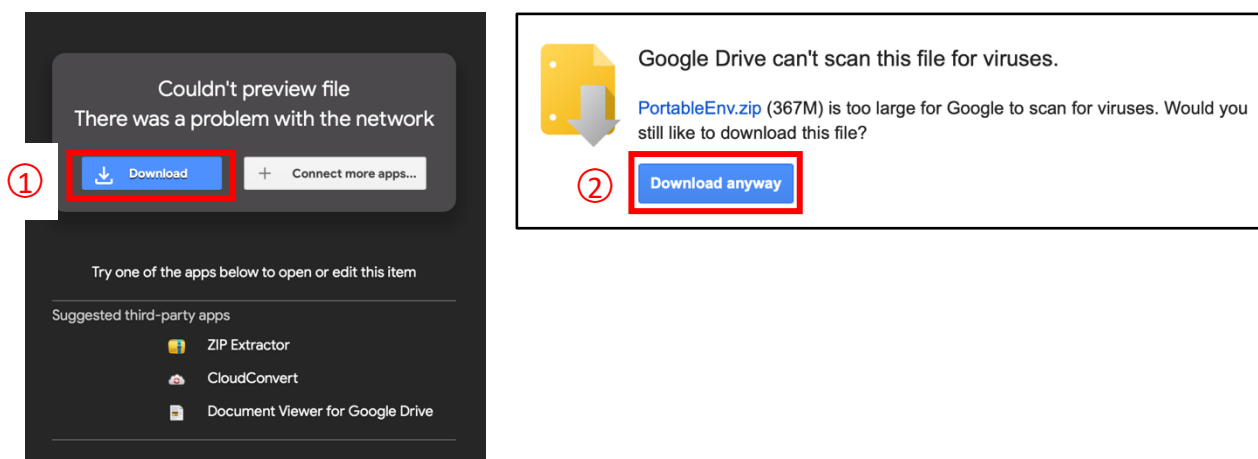
4.1. Set up the portable environment

The portable environment for running the QcDM Project, which includes R-portable (version 3.6.3) and two software (Pandoc and TinyTeX) for generating PDF reports.

Follow the instructions in Section 1.2 to download the QcDM Project as zip file from the GitHub repository, unzip it, rename the resulting folder as 'QcDM_Project folder', and move this folder to the root directory of the USB Drive.

Download the portable environment as a zip file named 'PortableEnv.zip' from the following link:

<https://drive.google.com/file/d/1bPk8pwZ2HaCDbXhP8e67wcVzWNXs4R76/view?usp=sharing>.



Unzip the file (see Section 1.2 for instructions) to a folder named 'PortableEnv', and move this folder to the root directory of the USB Drive.

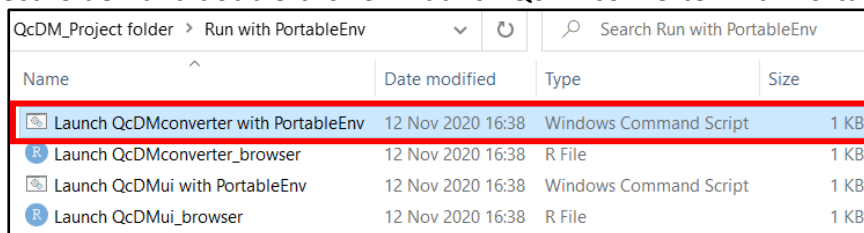
The root directory of the USB Drive should contain the following two folders, which take up approximately 1.8 GB on the disk:

USB Drive (E:)			Search USB D
Name	Date modified	Type	
Other files	12 Nov 2020 18:03	File folder	
QcDM_Project folder	12 Nov 2020 18:14	File folder	
PortableEnv	12 Nov 2020 18:19	File folder	

The portable environment has been configured by installing the R packages and software required by the QcDM Project, therefore users do not need to go through the installation steps in Section 1.1 and 1.3.

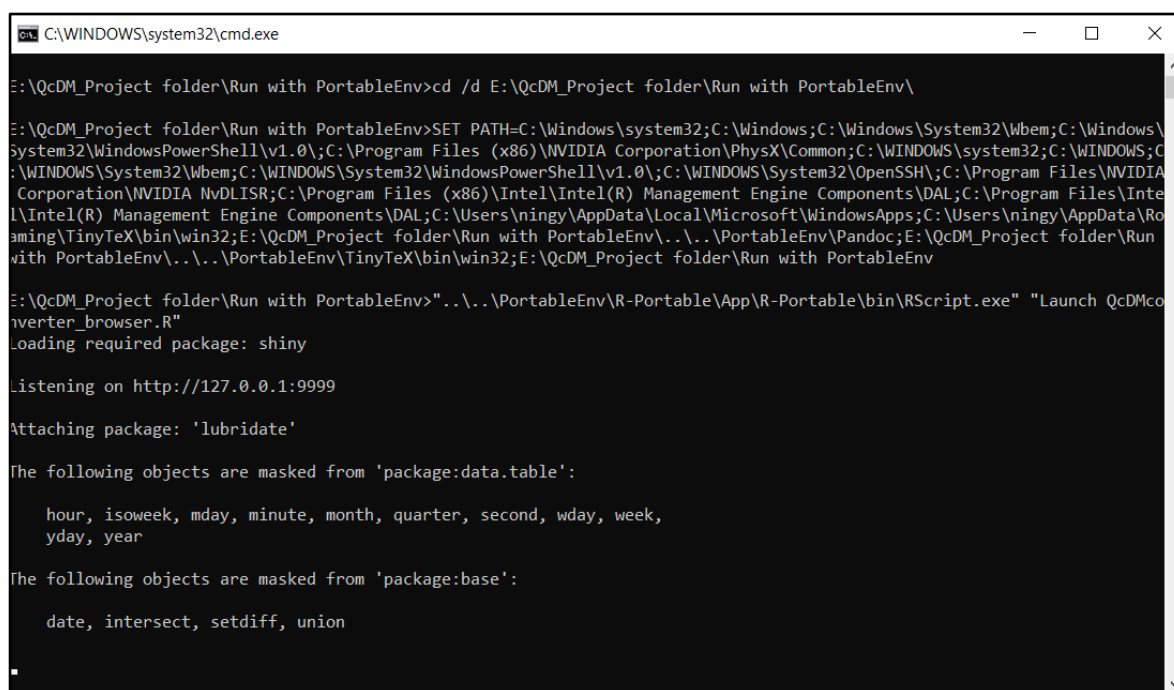
4.2. Run QcDMconverter with PortableEnv

To launch QcDMconverter from the USB Drive, go to the 'Run with PortableEnv' subfolder of 'QcDM_Project folder' and double-click on 'Launch QcDMconverter with PortableEnv.cmd':



Name	Date modified	Type	Size
Launch QcDMconverter with PortableEnv	12 Nov 2020 16:38	Windows Command Script	1 KB
Launch QcDMconverter_browser	12 Nov 2020 16:38	R File	1 KB
Launch QcDMui with PortableEnv	12 Nov 2020 16:38	Windows Command Script	1 KB
Launch QcDMui_browser	12 Nov 2020 16:38	R File	1 KB

The following command line window will pop-up:



```
C:\WINDOWS\system32\cmd.exe

E:\QcDM_Project folder\Run with PortableEnv>cd /d E:\QcDM_Project folder\Run with PortableEnv\

E:\QcDM_Project folder\Run with PortableEnv>SET PATH=C:\Windows\system32;C:\Windows;C:\Windows\System32\Wbem;C:\Windows\System32\WindowsPowerShell\v1.0\;C:\Program Files (x86)\NVIDIA Corporation\PhysX\Common;C:\WINDOWS\system32;C:\WINDOWS;C:\WINDOWS\System32\Wbem;C:\WINDOWS\System32\WindowsPowerShell\v1.0\;C:\WINDOWS\System32\OpenSSH\;C:\Program Files\NVIDIA Corporation\NVIDIA NvDLISR;C:\Program Files (x86)\Intel\Intel(R) Management Engine Components\DAL;C:\Program Files\Intel\Intel(R) Management Engine Components\DAL;C:\Users\ningy\AppData\Local\Microsoft\WindowsApps;C:\Users\ningy\AppData\Roaming\TinyTeX\bin\win32;E:\QcDM_Project folder\Run with PortableEnv\...\PortableEnv\Pandoc;E:\QcDM_Project folder\Run with PortableEnv\...\PortableEnv\TinyTeX\bin\win32;E:\QcDM_Project folder\Run with PortableEnv

E:\QcDM_Project folder\Run with PortableEnv>"..\..\PortableEnv\R-Portable\App\R-Portable\bin\RScript.exe" "Launch QcDMconverter_browser.R"
Loading required package: shiny

Listening on http://127.0.0.1:9999

Attaching package: 'lubridate'

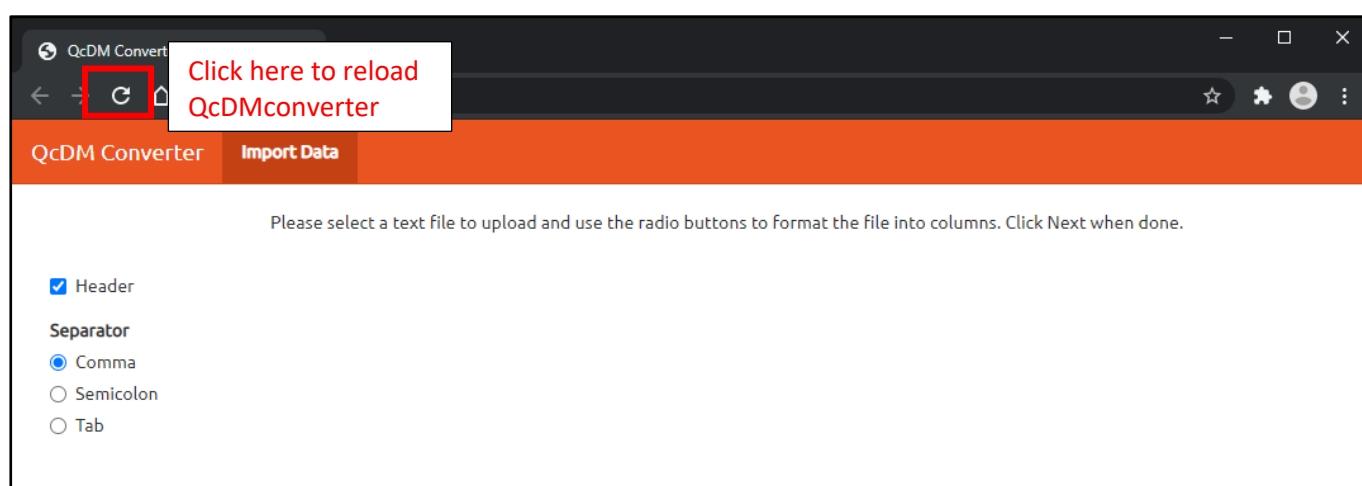
The following objects are masked from 'package:data.table':

    hour, isoweek, mday, minute, month, quarter, second, wday, week,
    yday, year

The following objects are masked from 'package:base':

    date, intersect, setdiff, union
```

and then QcDMconverter will open in the default web browser (in this example Chrome):



Users can follow the instructions in Section 2.1.2 or 2.2.1 to process glucose data.

After successful completion of data processing, users may reload QcDMconverter and proceed to additional data by clicking the reload button of the web browser (as shown in

the screenshot above). To close QcDMconverter, first close the QcDMconverter window in the web browser, then close the command line window.

4.3. Run QcDMui with PortableEnv

To launch QcDMui from the USB Drive, go to the 'Run with PortableEnv' subfolder of 'QcDM_Project folder' and double-click on 'Launch QcDMui with PortableEnv.cmd':

QcDM_Project folder > Run with PortableEnv		Search Run with PortableEnv	
Name	Date modified	Type	Size
Launch QcDMconverter with PortableEnv	12 Nov 2020 16:38	Windows Command Script	1 KB
Launch QcDMconverter_browser	12 Nov 2020 16:38	R File	1 KB
Launch QcDMui with PortableEnv	12 Nov 2020 16:38	Windows Command Script	1 KB
Launch QcDMui_browser	12 Nov 2020 16:38	R File	1 KB

The following command line window will pop-up:

```
C:\WINDOWS\system32\cmd.exe
```

```
date, intersect, setdiff, union
```

Attaching package: 'data.table'

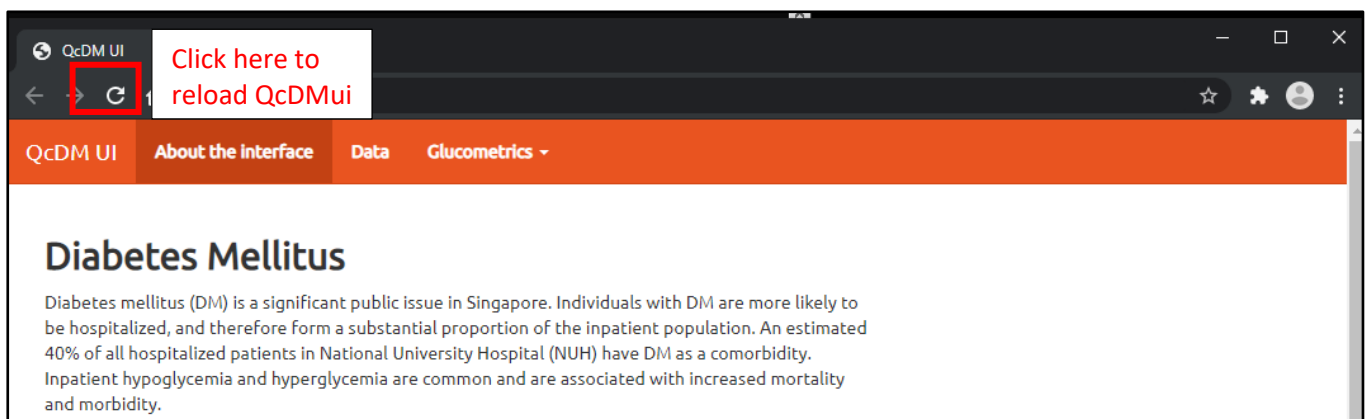
The following objects are masked from 'package:lubridate':

```
hour, isoweek, mday, minute, month, quarter, second, wday, week,
yday, year
```

Loading required package: xml2

```
SEND {"busy":"busy"}
SEND {"recalculating":{"name":"sampledata","status":"recalculating"}}
SEND {"recalculating":{"name":"sampledata","status":"recalculated"}}
SEND {"recalculating":{"name":"glucometric_definition","status":"recalculating"}}
SEND {"recalculating":{"name":"glucometric_definition","status":"recalculated"}}
SEND {"busy":"idle"}
SEND {"errors":{},"values":{"sampledata":<table class = 'table shiny-table table- spacing-s' style = 'width:auto;'>\n<thead>\n<tr>\n<th style='text-align: right;'> ADMISSION.ID </th>\n<th style='text-align: left;'> RESULT.DATE </th>\n<th style='text-align: right;'> RESULT </th>\n<th style='text-align: left;'> LOCATION </th>\n</tr>\n</thead>\n<tbody>\n<tr>\n<td align='right'> 6 </td>\n<td align='right'> 25/12/2014 19:54 </td>\n<td align='right'> 2.20 </td>\n<td> WardA </td>\n</tr>\n<tr>\n<td align='right'> 6 </td>\n<td align='right'> 24/12/2014 6:34 </td>\n<td align='right'> 2.70 </td>\n<td> WardA </td>\n</tr>\n<tr>\n<td align='right'> 9 </td>\n<td align='right'> 2/12/2014 1:30 </td>\n<td align='right'> 2.90 </td>\n<td> WardA </td>\n</tr>\n<tr>\n<td align='right'> 9 </td>\n<td align='right'> 2/12/2014 1:53 </td>\n<td align='right'> 2.90 </td>\n<td> WardA </td>\n</tr>\n<tr>\n<td align='right'> 29 </td>\n<td align='right'> 15/12/2014 11:42 </td>\n<td align='right'> 3.20 </td>\n<td> WardA </td>\n</tr>\n<tr>\n<td align='right'> 38 </td>\n<td align='right'> 4/12/2014 22:20 </td>\n<td align='right'> 3.30 </td>\n<td> WardA </td>\n</tr>\n</tbody>\n</table>","glucometric_definition":{"src":"data:image/png;base64 data"},"alt":""}}, "inputMessages":[]]
```

and then QcDMui will open in the default web browser (in this example Chrome):



Users can follow the instructions in Section 3.3 and 3.4 to process data and view glucometrics.

After successful completion of glucometrics generation, users may reload QcDMui and analyse additional glucose data by clicking the reload button of the web browser (as shown in the screenshot above). To close QcDMui, first close the QcDMui window in the web browser, then close the command line window.

Bibliography

1. Thomas P, Inzucchi SE. An internet service supporting quality assessment of inpatient glycemic control. In: Journal of Diabetes Science and Technology. SAGE Publications Inc.; 2008. p. 402–8.
2. Chen Y, Kao SL, Tai E-S, Wee HL, Khoo EYH, Ning Y, et al. Utilizing distributional analytics and electronic records to assess timeliness of inpatient blood glucose monitoring in non-critical care wards. BMC Med Res Methodol. 2016;16(1).