MANY LABS

INSTRUCTIONS

MANUAL

Made by:

ISEP Students (André Soares 1201314, Luís Ribeiro 1201184,
Miguel Ramos 1201247, Pedro Graça 1201188)

Many Labs is a chain of English Laboratories that operate all over the United Kingdom. With this new age of technology, Many Labs thought of the future and decided to create an application that could improve their services.

INTRODUCTION

1. Purpose and Scope of the Document

This document is the User Manual for the Many Labs Application. In the next sections, there is going to be information that explains the various functions, how to use them and, who can access them (according to the role).

Each role has a section containing its functions and what they do. There are also images explaining how the user should proceed on the usage of that function and what will happen after every action.

2. System Overview

The application is used by all the Many Labs laboratories and its employees. *The application permits a better organization of the services offered by the company, as it permits to have a program where all the actions are stored and easy to access to any employee.*

The application also permits the clients to consult the results of their tests without having to go to a Many Labs laboratory.

3. System Requirements

The system has some requirements, for example, the computer should have at least 8GB of RAM (to check this information, look at the configurations of your computer and check the storage configurations).

4. Software Installation:

To install the software on your computer, you will need to download the zip file containing the application and all the folders that it needs to work.

So firstly, start by downloading the zip file, after that go to the file and select the option of "Extract Here" (there is no problem if you select the option "Extract to File"). After the extraction is completed there will be a file with the name of the application on the folder where you did the last operation (if you want to, can move the application folder to where you prefer).

After these steps, the application should be able to be run on your computer, in case there is any problem, confirm if the installation process was followed right.

5. Initiating the Application

To initiate the software, you must start by opening the "Command Prompt" of Windows (in case your operative system is Mac, open the "Terminal"), where you will need to direct the command line into the folder where the jar file is at (for an easier process go into the folder where the application is and look for the directory "out" and then go into the folder "APPLICATION_NAME_jar," where the jar is located).

After redirecting the command line into the folder, you will need to insert the command "java -jar APPLICATION_NAME.jar" and after so the application should start normally.

SYSTEM FEATURES

1. Features Table

ID	FEATURE	DESCRIPTION	USERS	PAGE
1	Login	Permits the User to access its functions/features.	All Users	4
2	Checking test results	Permits the User to view the results of its performed tests.	Client	7
3	Personal Data Update	Permits the User to update its personal data.	Client	7
4	New Test Type	Permits the User to create a new Test Type that is performed by the Company.	Administrator	11
5	New Parameter Category	Permits the User to create a new Parameter Category that the Company has got.	Administrator	9
6	New Parameter	Permits the User to create a new Parameter that the Company analyses.	Administrator	10
7	Register Employee	Permits the User to register an Employee on the System.	Administrator	16
8	Register Clinical Analysis Laboratory	Permits the User to register a Clinical Analysis Laboratory on the System	Administrator	14
9	Send COVID-19 Report	Permits the User to send a report containing all the COVID-19 cases to the NHS.	Administrator	17
10	Register a new Client	Permits the User to register a new Client on the System.	Receptionist	20
11	Register a new Test	Permits the User to register a new Test on the System.	Receptionist	22
12	Record Samples of a Test	Permits the User to record the samples of a Test.	Medical Laboratory Technician	24
13	Record Results	Permits the User to register the results of a Test on the System.	Chemical Analysis Technologist	26
14	Consult Historical Tests	Permits the User to consult the data of made Tests.	Chemical Analysis Technologist	27
15	Write Report	Permits the User to write a report of a Test.	Specialist Doctor	31
16	Validate a Test	Permits the user to validate an existent Test on the System	Laboratory Coordinator	33

17	Import Clinical Test Data	Permits the user to import clinical Test data from a file to the System.	Laboratory Coordinator	38
18	Check the Efficiency	Permits the user to check the company efficiency in each period.	Laboratory Coordinator	34
19	Select Laboratory	Permits the user to select the Laboratory in which he/she is working.	Receptionist and Medical Laboratory Technician	19 and 23

2. Know the Development Team

To see the team involved in the process of the development of the application at the user should click a button in the login scene

```
Development Team:

    Luís Ribeiro - 1201184@isep.ipp.pt

    Pedro Graça - 1201188@isep.ipp.pt

    Miguel Ramos - 1201247@isep.ipp.pt

    André Soares - 1201314@isep.ipp.pt
```

3. Do Login

This functionality is only available to users that are registered on the application database, so if a user tries to do the login (with him/her being either a client or an employee), while not being registered, the login process will fail.

If the user inserts the wrong e-mail or password (or if the user is not registered to the system), the authentication will be failed, and the system will warn the user of so.

To do the Login you must:

1) **Enter the Login Menu:**

**2) Insert the User Identification (E-mail):**

3) Insert the Password

4. Client Functionalities

After the Client does the login, he/she will be met by the Client menu, in which all the functionalities are represented and able to be run:

4.1. Check the results of the Tests

Allows the Client to verify the results of his/her performed tests. If there are no performed tests, the application will warn the client of so. So, after clicking the button, the Client will be met by the following window:
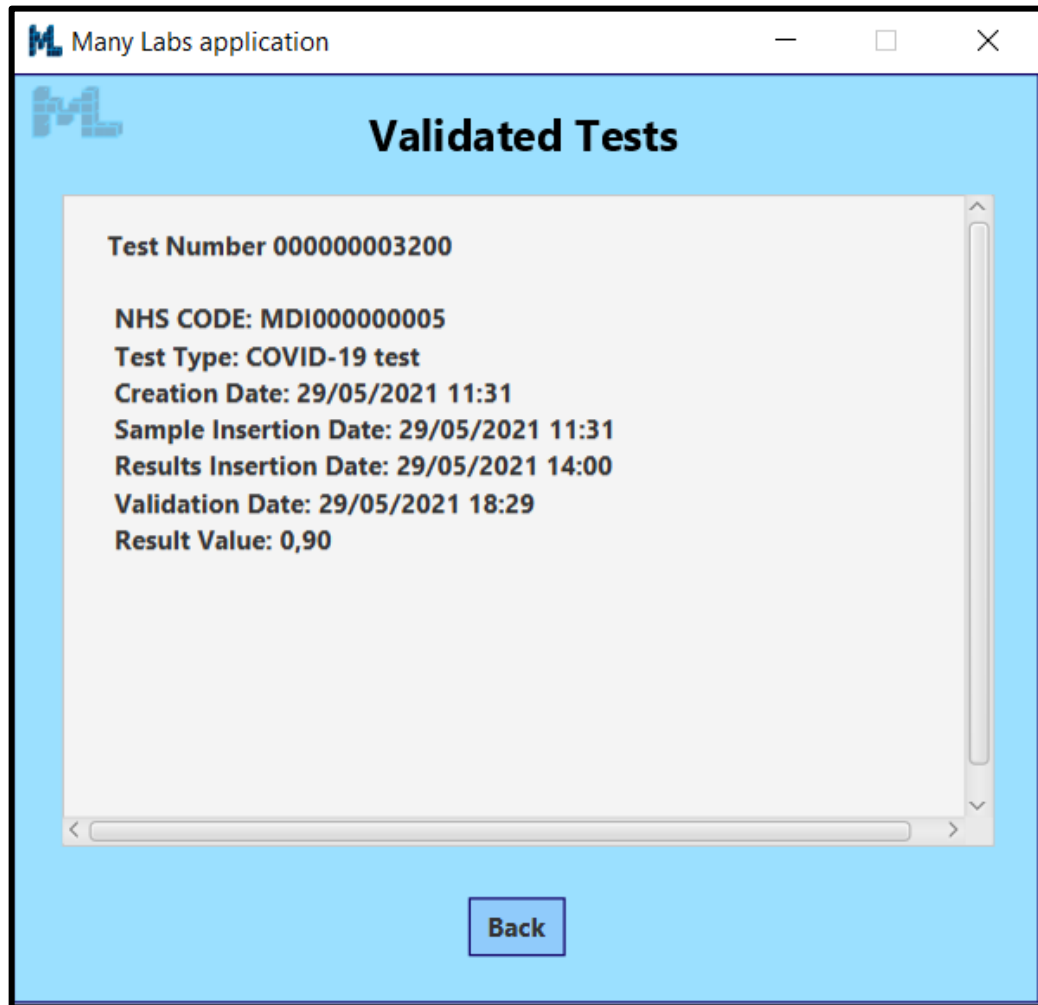
4.2. Update the personal data

If the Client selects the option "Update the Personal Date", he/she will be taken to a window that permits to change the data that can be changed (name, gender, phone number and address).

After changing the data, you must press the button "Update" and the System will warn you if the update was successful or not.
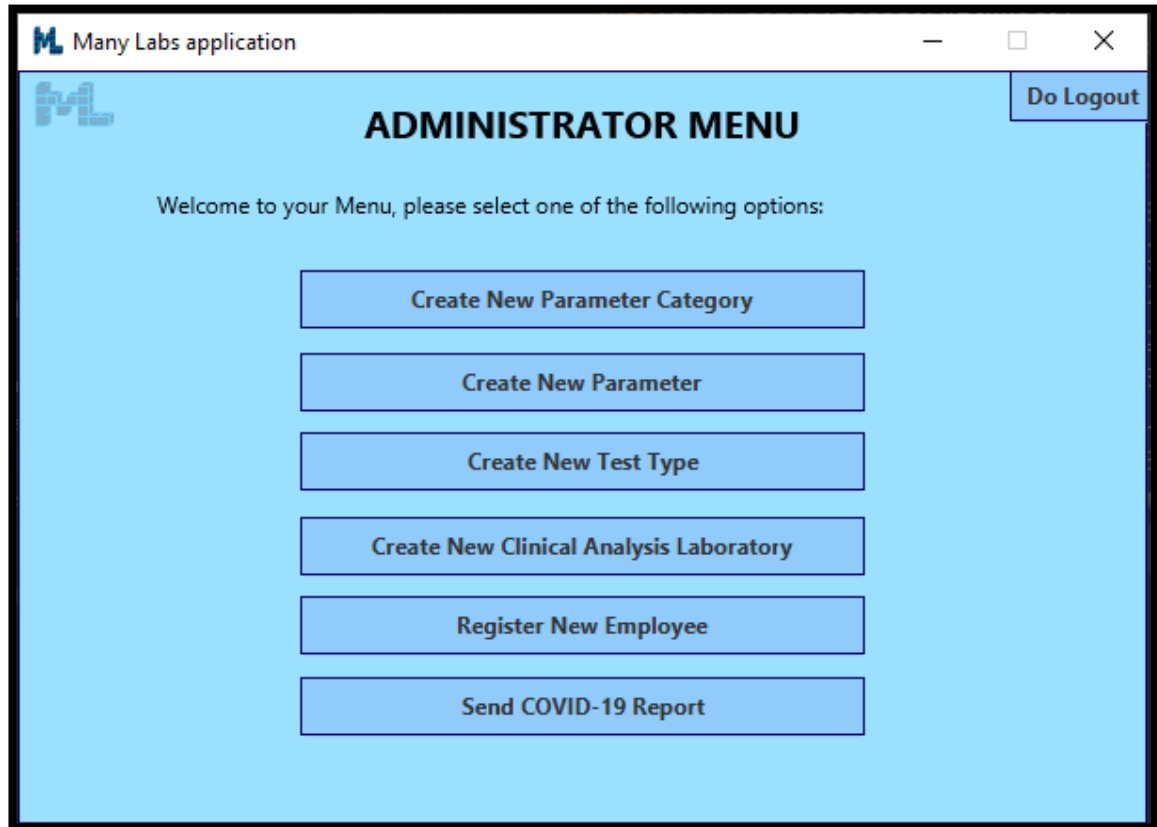
5. Administrator Functionalities

After the Administrator does the login, he/she will be given access to their menu, in which all the functionalities are represented and able to be run:

5.1. Create a New Parameter Category

If the Administrator selects the option "Create a New Parameter Category," he will be able to register a new Parameter Category to the Application. To do so, he will need to follow this process:

1) **Insert the Parameter Category Code (alphanumeric code)**

```
###NEW PARAMETER CATEGORY###

Parameter Category Code:
|
```

2) **Insert the Parameter Category Name**

```
Parameter Category Name:
|
```

3) **Confirm the inserted data**

```
###PARAMETER CATEGORY###

 - Code: 66666
 - Name: blood




Do you confirm this data?
|
```

5.2. Create a New Parameter

If the Administrator selects the option "Create a new Parameter," he/she will be able to create a new Parameter of a Parameter Category. For this functionality to work, the System needs to have at least one registered Parameter Category.

To create the new Parameter the Administrator will need to follow the next steps:

1) **Insert the Parameter Short Name**

```
###NEW PARAMETER###


Parameter Short Name:
|
```

2) **Insert the Parameter Code**

```
Parameter Code:
|
```

3) **Insert the Parameter Description**

```
Parameter Description:
|
```

4) **Select the Parameter Category of the Parameter**

```
PARAMETER CATEGORY LIST:
1. ##Parameter Category##
 Code: abcde
 Name: l
2. ##Parameter Category##
 Code: 12345
 Name: Hemogram
3. ##Parameter Category##
 Code: 12332
 Name: Covid
4. ##Parameter Category##
 Code: 76767
 Name: y
5. ##Parameter Category##
 Code: 66666
 Name: blood


0 - Cancel


Type your option:
|
```

5) Confirm the inserted data

```
###PARAMETER CATEGORY###

 - Code: 77777
 - Name: Hemogram



Do you confirm this data?

|
```

5.3.   Create a New Test Type

If the Administrator selects the option "Create a new Test Type" he/she will be able to register a Test Type that the Company performs into the System. Be aware that the non-existence of Parameter Categories on the System will block the progress of this function.

At the end of this function, the Application will ask if the Administrator wants to see the list of the Test Types that are on the System.

To do so, the process to be followed is:

1) Insert the Test Type Code (5-character alphanumeric code):

```
###NEW TEST TYPE###

Code:
|
```

2) Insert the Test Type Description:

```
Description:
|
```

3) Insert the Collection Method:

```
Collection Method:
|
```

4) Confirm the created Test Type:

```
###TEST TYPE###

 - Code: 33333
 - Description : descr
 - Collection Method : collec




Are you sure you want to create a Test Type with these data?

|
```

5) Select the Parameter Categories to associate to the Test Type (able to select multiple):

```
List of categories available in the system for this test type
1. ##Parameter Category##
 Code: abcde
 Name: l
2. ##Parameter Category##
 Code: 12345
 Name: Hemogram
3. ##Parameter Category##
 Code: 12332
 Name: Covid
4. ##Parameter Category##
 Code: 76767
 Name: y
5. ##Parameter Category##
 Code: 66666
 Name: blood

0 - Cancel

Type your option:
|
```

6) **Confirm the selected Parameter Categories:**

```
##Parameter Category##
 Code: 12345
 Name: Hemogram



Are you sure you want to add this Parameter Category to your test type

|
```

7) **Select the External Module to be used:**

```
List of external module in the system
1. Covid Module
2. Blood Module 1
3. Blood Module 2

0 - Cancel


Type your option:
|
```

5.4. Create Clinical Analysis Laboratory

If the Administrator selects the option "Create Clinical Analysis Laboratory," he/she will be able to register a Clinical Analysis Laboratory into the System. If the System's database does not have a registered Test Type, this functionality will be unable to do this function.

To register a Clinical Analysis Laboratory, the steps to be followed are:

1) **Insert the Laboratory Id of the Clinical Analysis Laboratory:**

```
Laboratory Id:
|
```

2) **Insert the Address of the Clinical Analysis Laboratory**

```
Address:
|
```

3) **Insert the Name of the Clinical Analysis Laboratory**

```
Name:
|
```

4) **Insert the Phone Number of the Clinical Analysis Laboratory**

```
Phone Number:
|
```

5) **Insert the Tax Identification Number of the Clinical Analysis Laboratory**

```
Tax Identification Number (TIN):
|
```

6) **Choose a Test Type (by the number)**

```
What is the Test Type that do you want?
1.
##Test Type##
 Code: 12345
 Description: description
 Collection Method: method
2.
##Test Type##
 Code: 54321
 Description: descriptionn
 Collection Method: method
3.
##Test Type##
 Code: Blood
 Description: Blood test
 Collection Method: syringe
4.
##Test Type##
 Code: Covid
 Description: COVID-19 test
 Collection Method: Swab
5.
##Test Type##
 Code: 33333
 Description: descr
 Collection Method: collec

0 - Cancel

Type your option:
|
```

7) **Confirm the addition of the Test Type**

```
##Test Type##
 Code: Blood
 Description: Blood test
 Collection Method: syringe



Are you sure you want to add this Test Type to your Clinical Analysis Laboratory?

|
```

8) **Show the List of Test Types again**
9) **Asks if the User wants to save the Clinical Analysis Laboratory**

```
Do you want to see the Clinical Analysis Laboratory Store? (s/n)


|
```

5.5. Register New Employee

If the Administrator selects the option "Register New Employee", he/she will be able to register an Employee to the Application. By doing so the registered Employee will be able to do the login into the application (the login information is sent to the person by an automatic e-mail, for more information check the section "11. Automatic Functionalities – Registration Notification").

To do this function correctly, the Administrator needs to follow the next steps:

1) **Insert the Employee's Organization Role**

```
##EMPLOYEE ROLES##
1. ADMINISTRATOR
2. CHEMICAL ANALYSIS TECHNICIAN
3. LABORATORY COORDINATOR
4. MEDICAL LABORATORY TECHNICIAN
5. RECEPTIONIST
6. SPECIALIST DOCTOR

0 - Cancel

Select the role:
|
```

2) **Insert the Employee's Name**

```
Name:
|
```

3) **Phone Number (11 numbers)**

```
Phone Number:
|
```

4) **Insert the Employee's E-mail**

```
E-mail:
|
```

5) **Insert the Employee's SOC Code (4 numbers)**

```
SOC Code:
|
```

6) **Insert the Employee's Address**

```
Address:

|
```

7) (If the selected role was Specialist Doctor) Insert the Specialist Doctor's Doctor Index Number (6 numbers)

```
Doctor Index Number:

|
```

8) Confirm all the inserted data (by pressing the key "Y")

```
##EMPLOYEE##

 Name: Test Person
 Phone Number: 91331924910
 E-mail: testPerson@manyLabs.com
 Address: London, United Kingdom
 Organization Role: SPECIALIST DOCTOR
 SOC Code: 1905
 Doctor Index Number: 193862




Do you confirm the shown data?

|
```

5.6.   Send Sars-CoV-2 Report to NHS

If the Administrator selects the option "Send Covid-19 Report", he/she will be able to make a custom report to be sent to the NHS.

The User needs to select all the data, starting from the Regression Type to the percentage value to be used on the Predictions. Be aware that the Significance Levels are percentages, so if you insert the value 5, it will correspond to 5% (0.05).

1)   Select the data to customize the Covid-19 Report

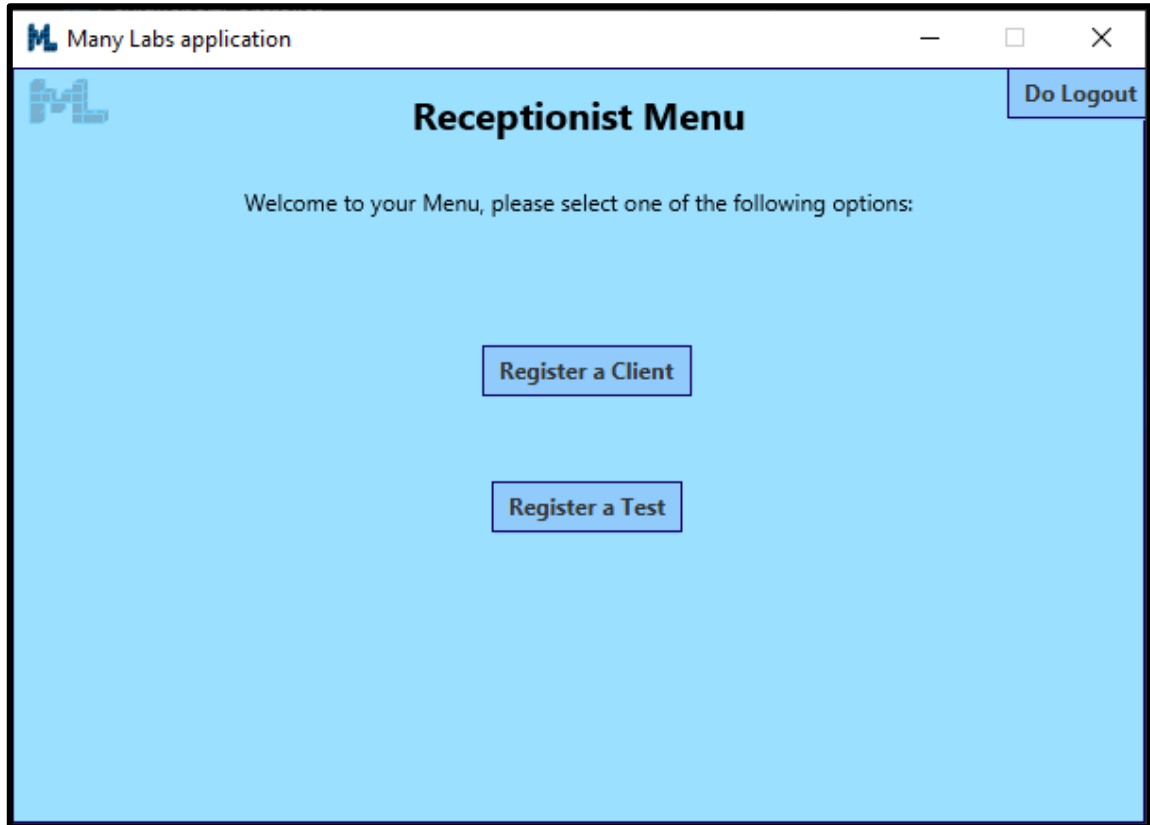2) **(If the Regression Type is Simple Linear Regression) Select the Independent Variable and Hypothesis Parameter to be used**

6. Receptionist Functionalities

After the Receptionist does the login, he/she will be met by their menu, in which all the functionalities are represented and able to be run:

6.1. Select the Laboratory

Allows the Receptionist to select the Clinical Analysis Laboratory that he/she operates.

```
Laboratories
1. ##Clinical Analysis Laboratory##
 LaboratoryId: 001DO
 Address: Chelsea Street
 Name: CheLab
 Phone Number: 12345678912
 Tax Identification Number: 1234567891
2. ##Clinical Analysis Laboratory##
 LaboratoryId: 001MA
 Address: Norwich Street
 Name: NorLab
 Phone Number: 12345678911
 Tax Identification Number: 1234567899
3. ##Clinical Analysis Laboratory##
 LaboratoryId: 001SO
 Address: London Street
 Name: LonLab
 Phone Number: 12345678913
 Tax Identification Number: 1234567199
4. ##Clinical Analysis Laboratory##
 LaboratoryId: 001LR
 Address: Yorkshire Street
 Name: YorLab
 Phone Number: 12345678914
 Tax Identification Number: 1234567299
5. ##Clinical Analysis Laboratory##
 LaboratoryId: 001WA
 Address: West Street
 Name: WesLab
 Phone Number: 12345678915
 Tax Identification Number: 1234567399
6. ##Clinical Analysis Laboratory##
 LaboratoryId: 001LN
 Address: East Street
 Name: EastLab
 Phone Number: 12345678916
 Tax Identification Number: 1234567499

0 - Cancel

Type your option:
|
```

6.1. Register a new Client

Allows the Receptionist to register a new Client on the System. The registered client will be able to access his/her functionalities after the registration, with the

information that is sent in an e-mail (for more information please check the section "11. Automatic Functionalities – Registration Notification").

To do this function correctly, the Receptionist needs to follow the next steps:

1) **Insert Client Name of the Client**

```
Name:
|
```

2) **Insert Email of the Client**

```
Email:
|
```

3) **Insert Tax Identification Number of the Client**

```
Tax Identification Number (TIN):
|
```

4) **Insert Citizen Card Number of the Client**

```
Citizen Card Number:
|
```

5) **Insert National Healthcare Service number of the Client**

```
National Healthcare Service (NHS) Number:
|
```

6) **Insert Birth Date of the Client**

```
Birth Date (DD/MM/YYYY):
|
```

7) **Insert Gender of the Client**

```
Gender (Male/Female):
|
```

8) **Insert Phone Number of the Client**

```
Phone Number:
|
```

9) **Insert Address of the Client**

```
Address:
|
```

6.2. Register a new Test

Allows the Receptionist to register a new Test (that will be performed to a certain Client) on the System.

1) Insert Tax Identification number to Test:

```
Tax Identification Number (TIN):
|
```

2) Insert NHS code

```
NHS Code:
|
```

3) Confirm the data inputted by the User

```
Tax Identification Number (TIN) : 1234567890
NHS Code: 123456789012



Do you want to confirm this data? (s|n)

|
```

7. Medical Laboratory Technician Functionalities

After the After the Medical Laboratory Technician does the login, he/she will be met by their menu, in which all the functionalities are represented and able to be run:

7.1. Choose the Clinical Analysis Laboratory to Operate:

Allows the Medical Laboratory Technician to select the Clinical Analysis Laboratory that he/she operates.

```
Laboratories
1. ##Clinical Analysis Laboratory##
 LaboratoryId: 001DO
 Address: Chelsea Street
 Name: CheLab
 Phone Number: 12345678912
 Tax Identification Number: 1234567891
2. ##Clinical Analysis Laboratory##
 LaboratoryId: 001MA
 Address: Norwich Street
 Name: NorLab
 Phone Number: 12345678911
 Tax Identification Number: 1234567899
3. ##Clinical Analysis Laboratory##
 LaboratoryId: 001SO
 Address: London Street
 Name: LonLab
 Phone Number: 12345678913
 Tax Identification Number: 1234567199
4. ##Clinical Analysis Laboratory##
 LaboratoryId: 001LR
 Address: Yorkshire Street
 Name: YorLab
 Phone Number: 12345678914
 Tax Identification Number: 1234567299
5. ##Clinical Analysis Laboratory##
 LaboratoryId: 001WA
 Address: West Street
 Name: WesLab
 Phone Number: 12345678915
 Tax Identification Number: 1234567399
6. ##Clinical Analysis Laboratory##
 LaboratoryId: 001LN
 Address: East Street
 Name: EastLab
 Phone Number: 12345678916
 Tax Identification Number: 1234567499

0 - Cancel

Type your option:
|
```

7.2. Record the Samples of a Test:

In case the Medical Laboratory Technician selects the option "Record the Samples of a Test", he/she will be able to record one or more samples of a certain test (each sample will be associated with a barcode, that is generated automatically by the application, for more information, please consult the section "11. Automatic Functionalities – Barcode Creation").

It is important to remember that this function is only available if the system's database has at least one

1) Select the Test from Test List

```
List of Tests without Samples
1. ##Test##
 CODE: 000000000001
 NHS CODE: 0000000000ee
 Creation Date: 16/06/2021 17:30

##Test Type##
 Code: Covid
 Description: COVID-19 test
 Collection Method: Swab
 [
##Parameter##
 Code: 00000
 Short Name: IgGAN
 Description: Sars
 ]
 [##Parameter Category##
 Code: 12332
Name: Covid
]


0 - Cancel

What is the Test that you want to add the Samples?
|
```

2) Insert the number of samples to record:

```
How many Samples do you want to create?
|
```

3) Confirmation of creating the sample:

```
Creating Samples...
30000003170
OPERATION SUCCESS
Test was saved with all Samples.
```

Number of the Barcode of the Sample

8. Clinical Chemistry Technologist Functionalities

After the Clinical Chemistry Technologist does the login, he/she will be met by their menu, in which all the functionalities are represented and able to be run:
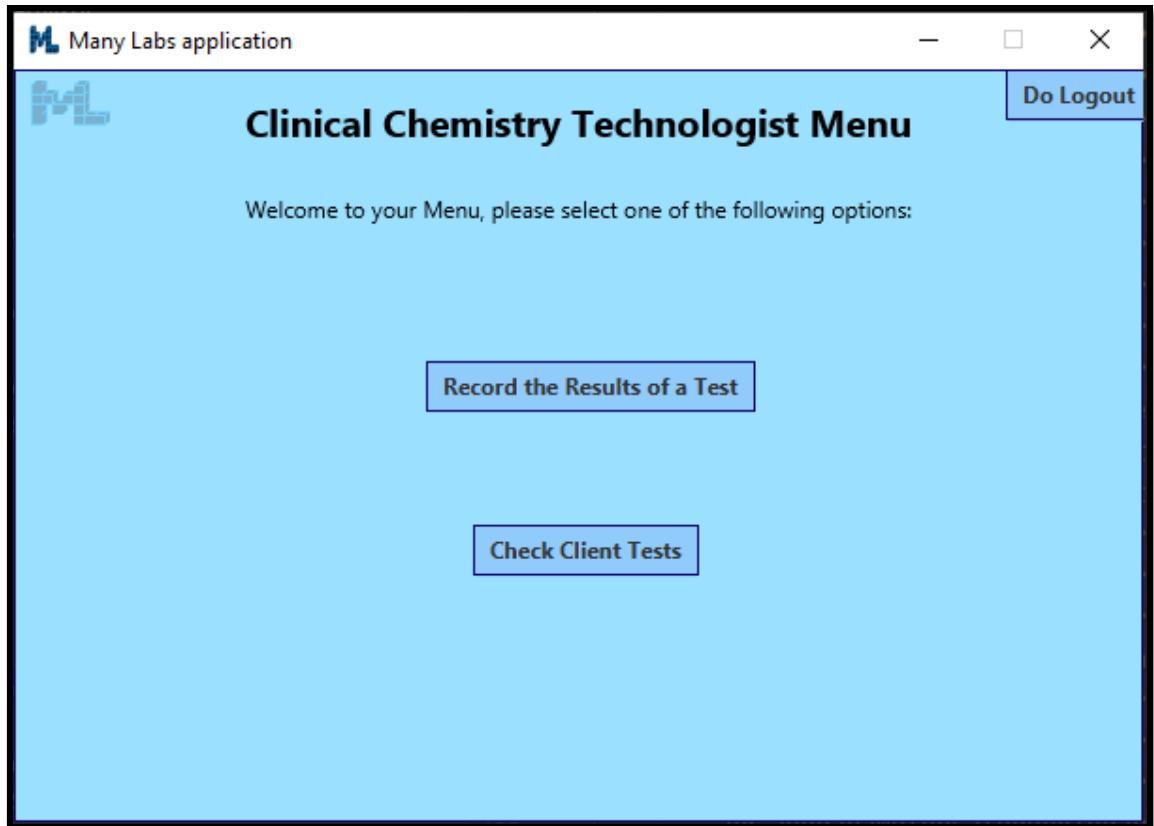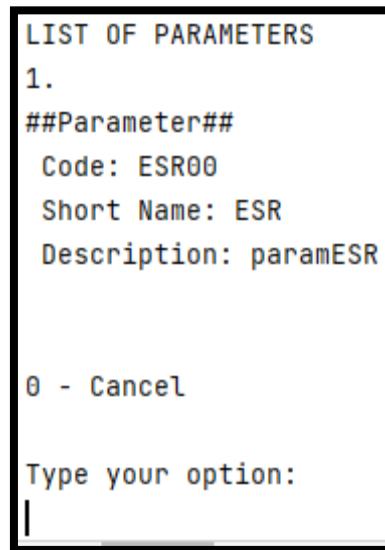

8.1. Record the Results of a Test

If the Chemical Analysis Technologist selects the option "Record Test Results," he/she will be able to record the results of on tests. The Chemical Analysis Technologist should be aware that if no tests are waiting for the recording of its results, the function will not run.

1) **Insert the Barcode Number of the Test**

2) Select the Parameter to add a Result

```
LIST OF PARAMETERS
1.
##Parameter##
 Code: ESR00
 Short Name: ESR
 Description: paramESR


0 - Cancel

Type your option:
|
```
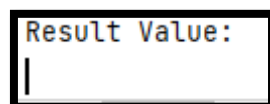
3) Introduce Result Value of the Result (Cannot be negative)
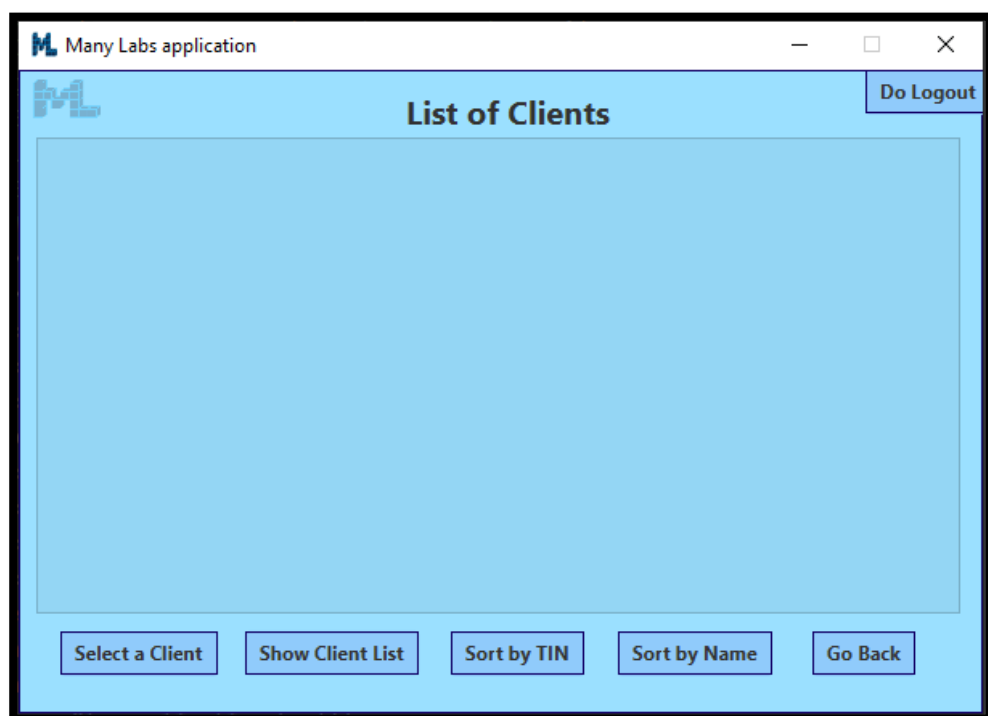
```
Result Value:
|
```

8.2.   Check Client Tests

If the Chemical Analysis Technologist selects the option "Check Client Tests," he/she will be able to view the results of all the done tests.

This function also allows the user to sort the tests by the Client's Tax Identification Number or the Client's Name.

1) Show List
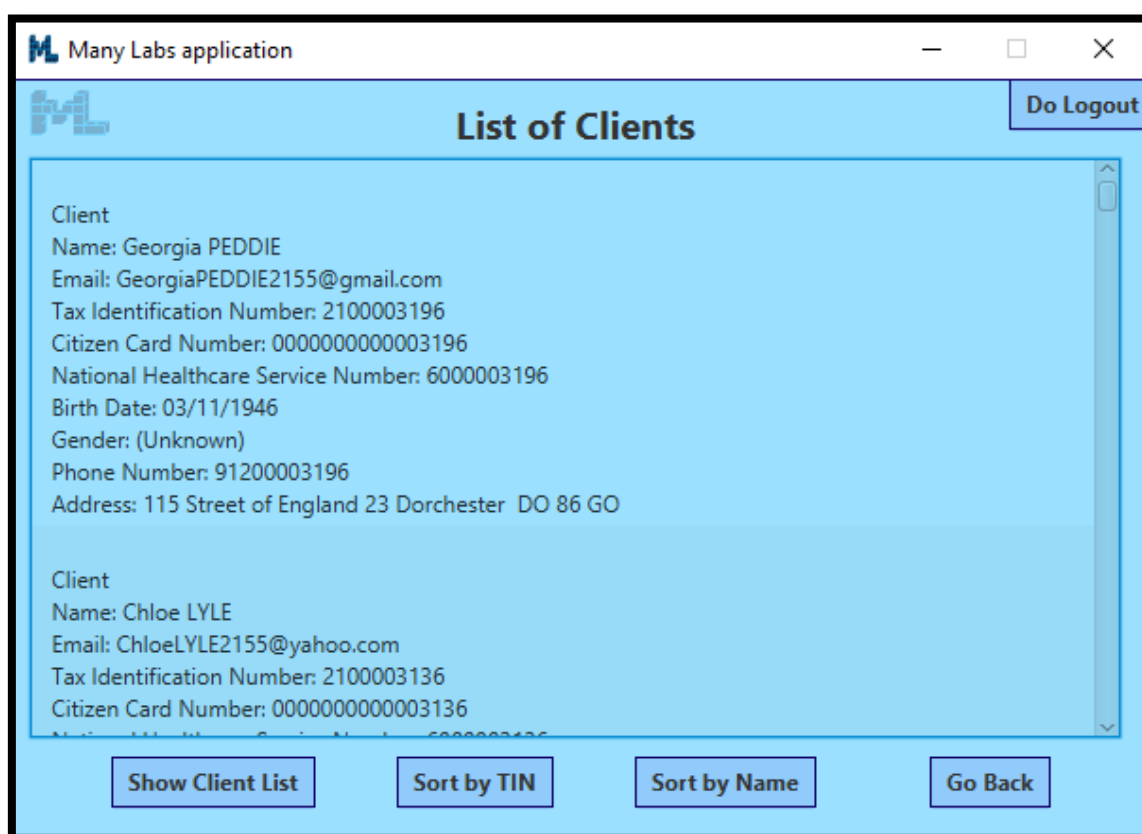
2) Sort by TIN
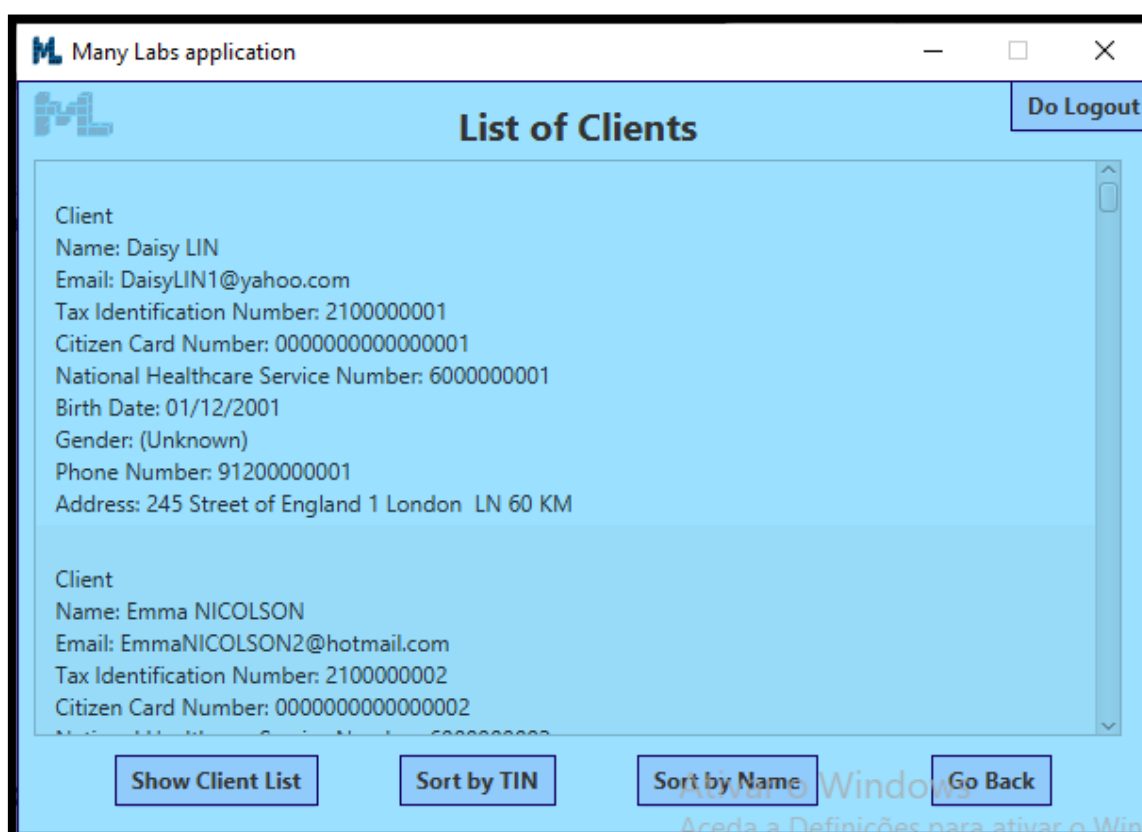
3) Sort by Name
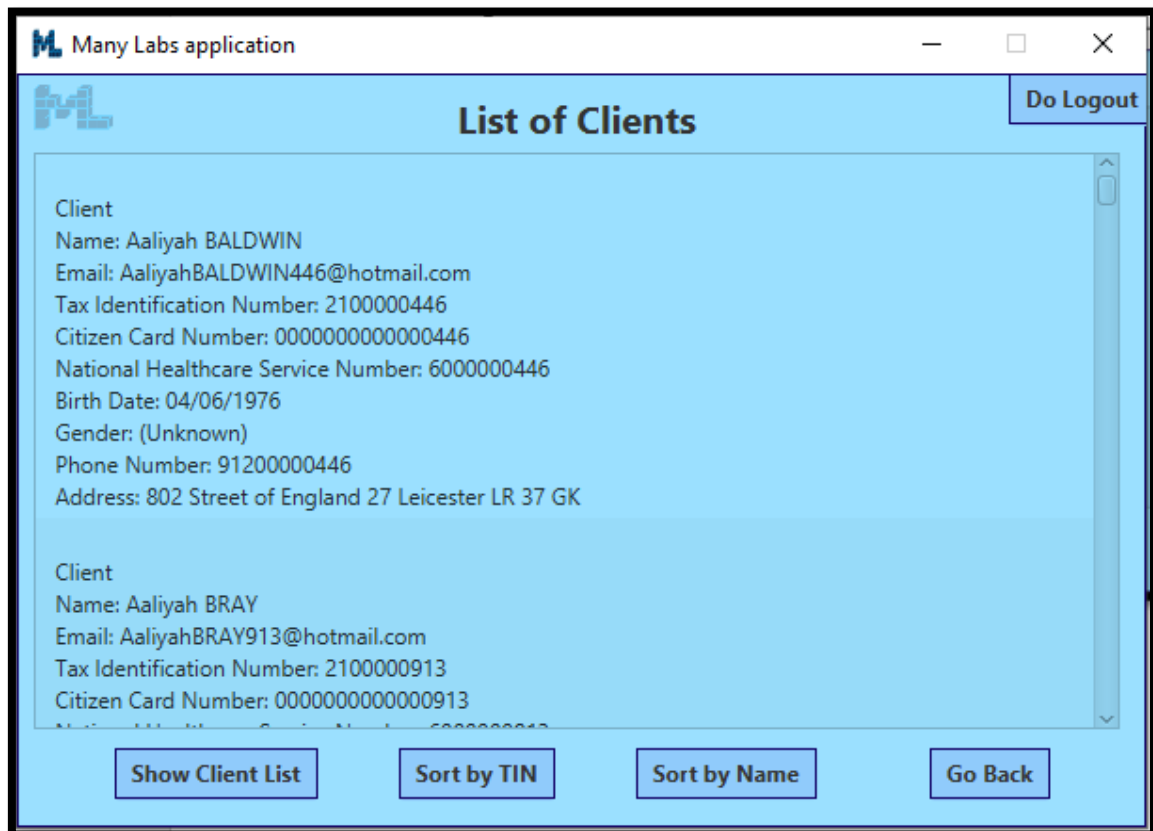
4) Select Client
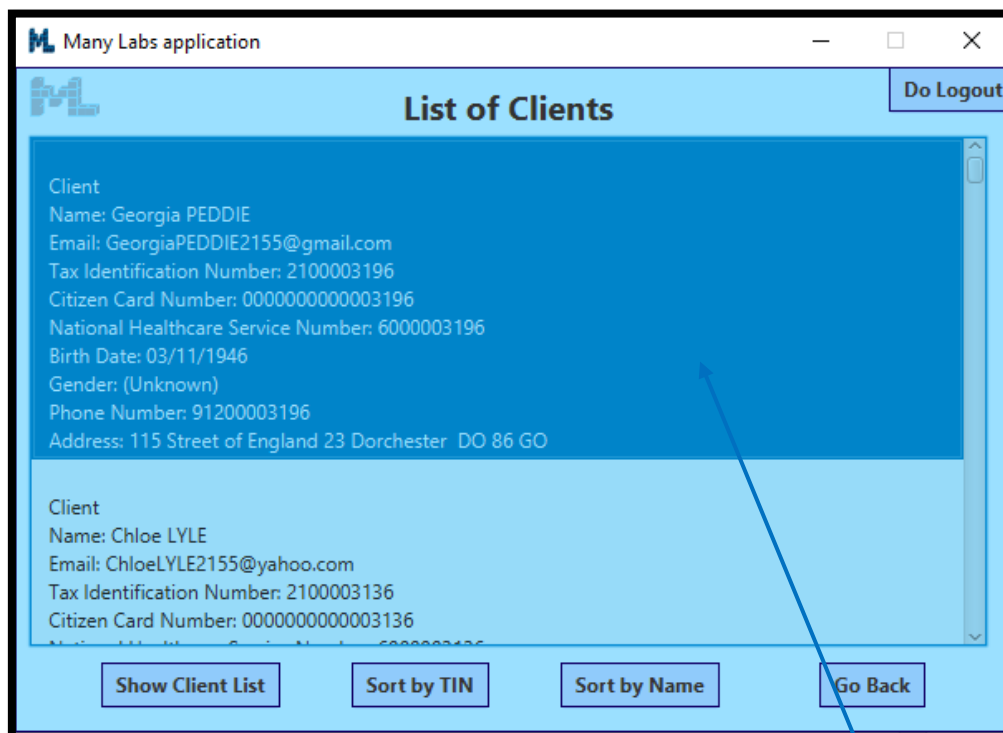
If you make a double, click another scene will be opened.

Select the Client doing a double click.

9. Specialist Doctor Functionalities

Specialist Doctor does the login, he/she will be met by their menu, in which all the functionalities are represented and able to be run:

9.1. Write a Report

If the Specialist Doctor selects the option "Write a Report" he/she will be able to write a report of a test that already has results. The User should be aware that if there are no tests with results on the System, this functionality will not be run.

1) **Select one Test to write a Report**

```
TESTS WITHOUT REPORT
1. ##Test##
 CODE: 000000000001
 Creation Date: 16/06/2021 22:49
 Sample Insertion Date: 16/06/2021 22:50
 Results Insertion Date: 16/06/2021 22:52



0 - Cancel

Type your option:
|
```

2) **Confirm the selection of the Test**

```
Do you confirm the selected Test?
|
```

3) Write the Report

```
RESULTS OF THE TEST

##Parameter##
 Code: ESR00
 Short Name: ESR
 Description: paramESR
 Result Value: 10,00
 Metric: mm/hr
 Reference Values: Lower Reference Value: 1,00 | Upper Reference Value: 10,00




Write the Test Report (Limit: 400 words):
|
```

4) Confirm the written Report

```
TEST REPORT | Test Code: 000000000001
 The Client is good.
 Written by: Specialist Doctor | E-mail: specdoc@gmail.com


Do you confirm the shown data?

|
```

5) (Optional) Confirming the writing of another Report (If there are other Tests waiting for a Report they will appear, in this case, there are none)

```
WARNING: There are no tests waiting for a Report.
OPERATION FINISHED
```

10. Laboratory Coordinator Functionalities

After a successful login made by a Laboratory Coordinator, he/she will be given access to their Menu, being able to select the function to be ran:
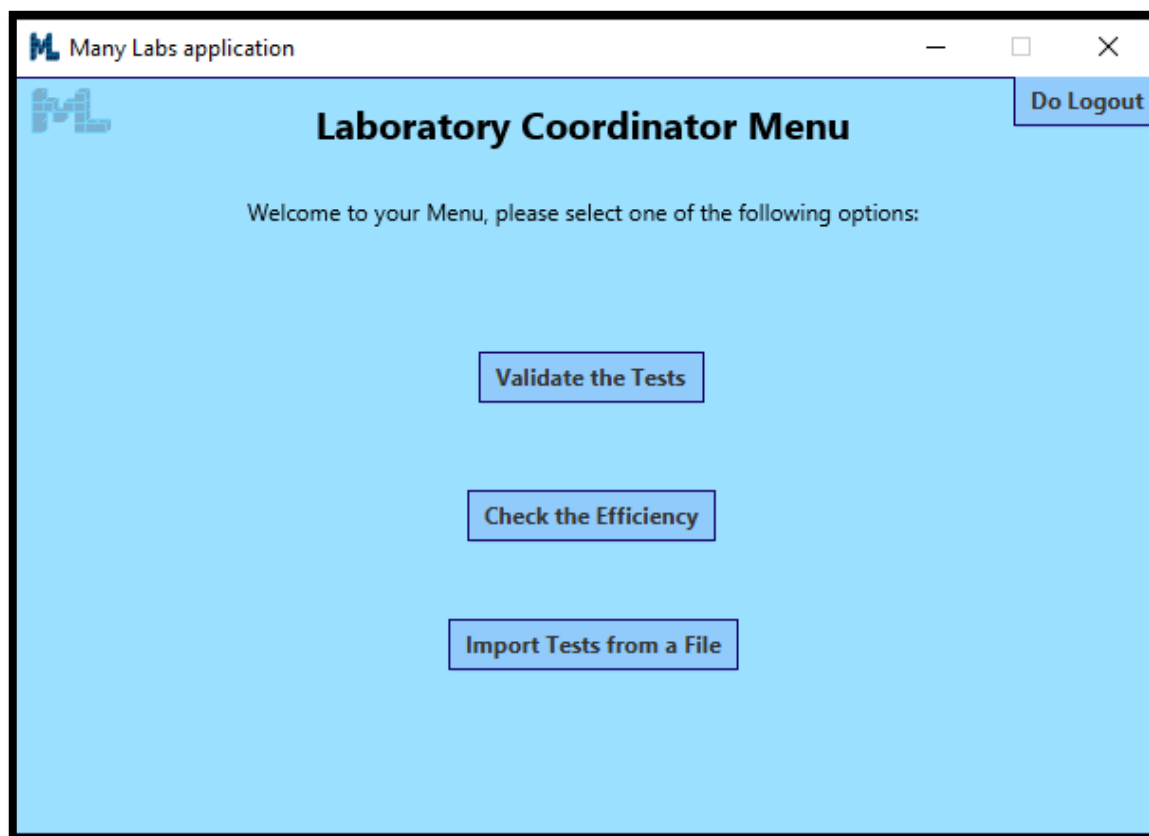
10.1. Validate the Tests

Allows the Laboratory Coordinator to validate all or a subset of tests. The clients that got their tests validated will receive a notification warning them of so (for more information please check the section "11. Automatic Functionalities – Validation Notification").

To validate existent tests the laboratory coordinator first must choose between validating all the waiting to be validated tests or only a subset of them. If the laboratory coordinator chooses the first option, the system will show all the tests available to be validated and ask to confirm the action. If the laboratory coordinator chooses the second one, the system will show all the tests until the laboratory coordinator does not want to continue choosing the tests to be validated.

To validate a Test, we have two options:

1. Validate all available tests currently in the system.
2. Choose a subset of tests to validate.

They do the same thing but with the option to validate a subset of tests or all at the same time

1) Option to validate all the tests

```
List of tests that are currently available to be validated
1. ##Test##
 CODE: 000000000001
 NHS CODE: 123456789012
 Creation Date: 16/06/2021 22:49
 Sample Insertion Date: 16/06/2021 22:50
 Results Insertion Date: 16/06/2021 22:52
 Report Date: 16/06/2021 22:57



0 - Cancel



Would you like to validate all the shown tests?

|
```

2) Confirmation

```
Tests validation done with success
```

10.2. Check the Efficiency

Allows the Laboratory Coordinator to check the efficiency of the Company during certain intervals, by the visualization of graphics and statistics.

1) Select the Dates and the Algorithm

2) **Check the Information of the Performed Tests and choose the graph to be seen (If you select the Performed Tests Graph, you will need to select the graph independent variable: by days, weeks, months, and years.) (This is only an illustrative image)**
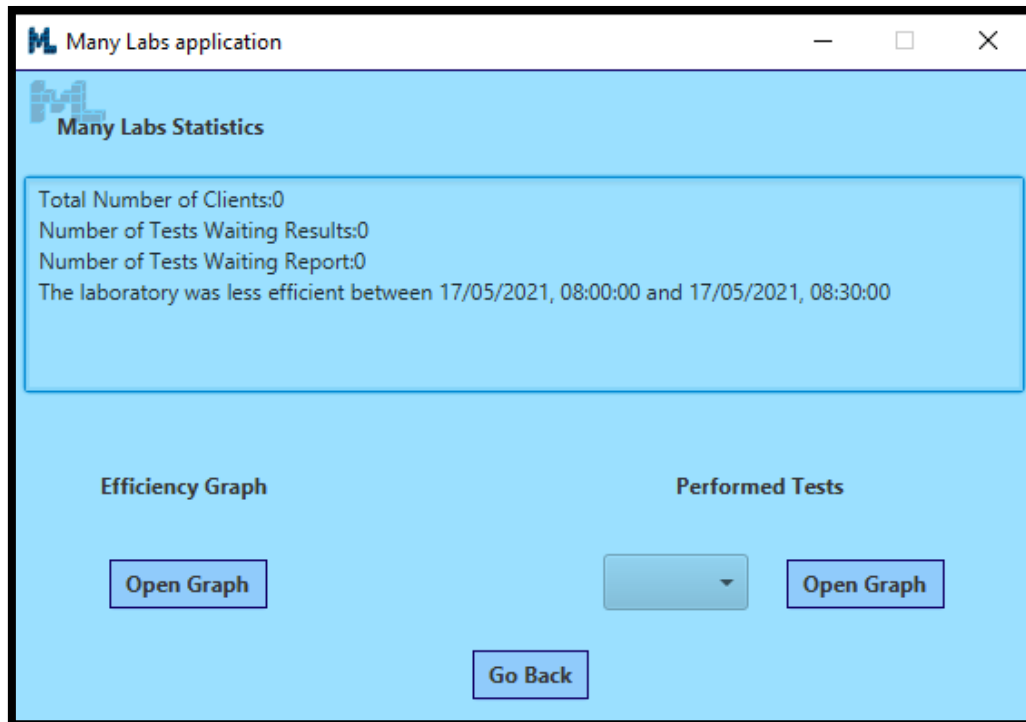
3) **View the Efficiency Graph (this is only an illustrative image)**
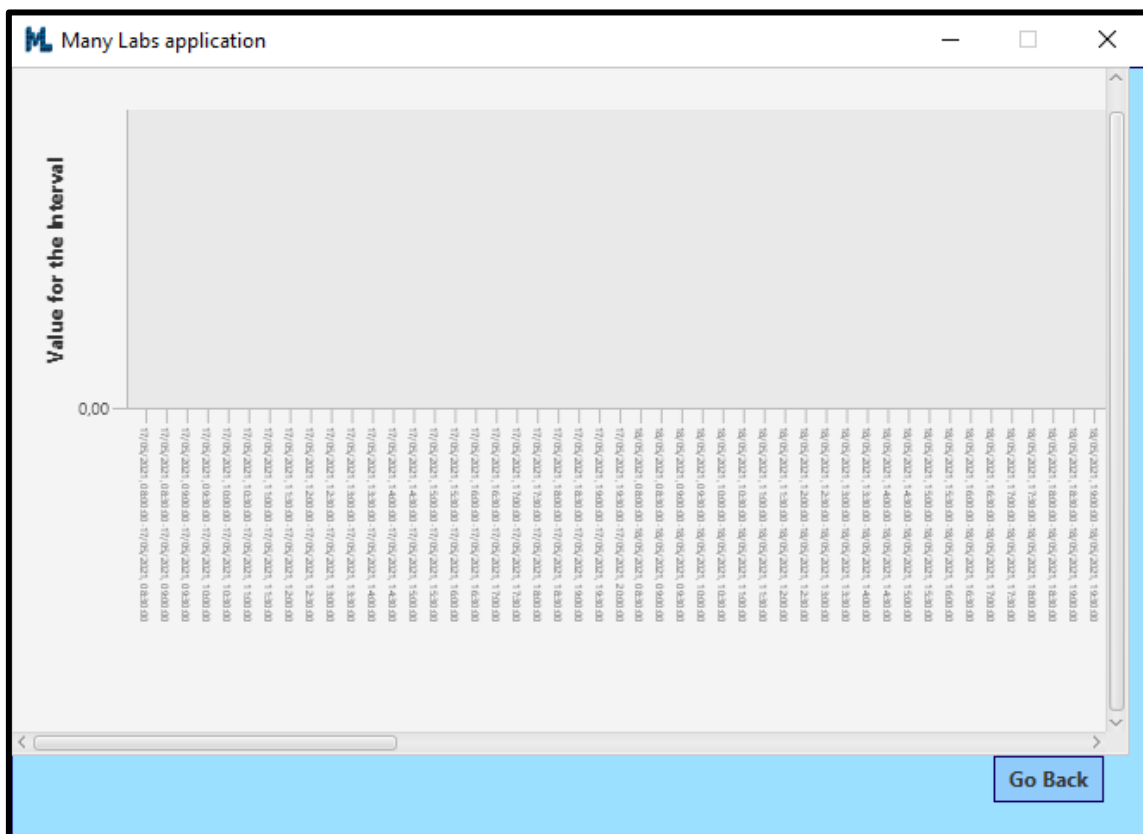
4) View the graph with the performed tests (this is only an illustrative image)
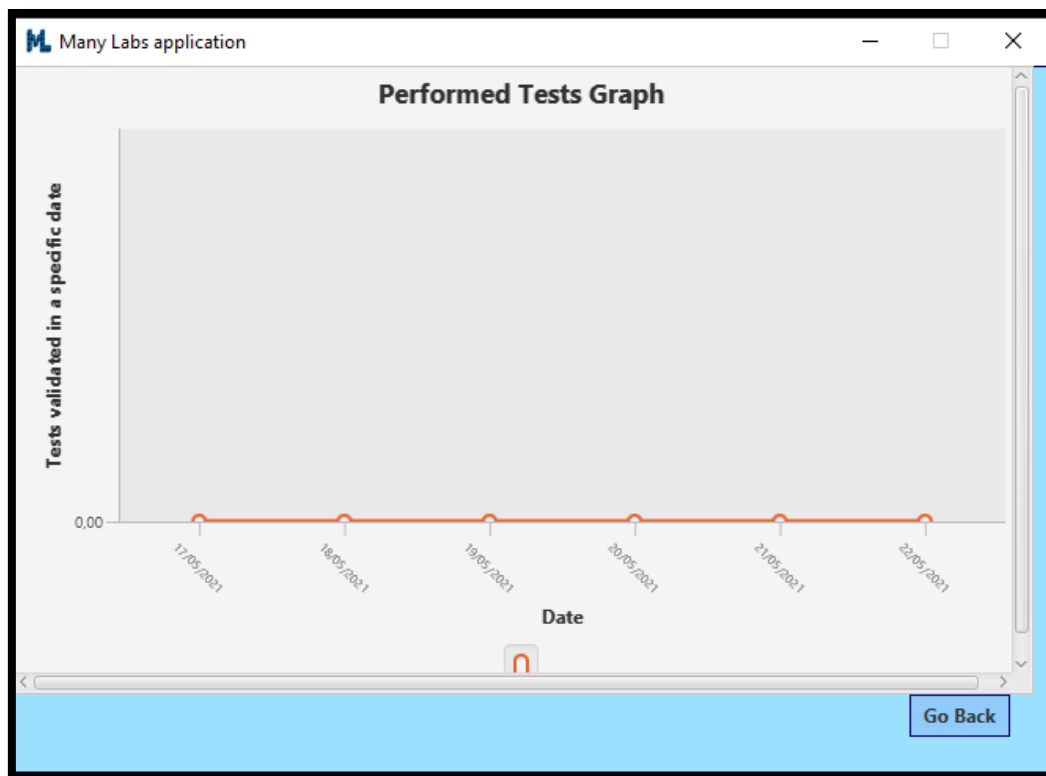
10.3. Import Tests from a File

Allows the Laboratory Coordinator to import tests from a file (.csv format) to the system. If the file contains errors, the system will warn the Laboratory Coordinator of so. To import tests into the system a CSV valid file must exist in the system.

1) Chose a CSV type file from the file explorer.
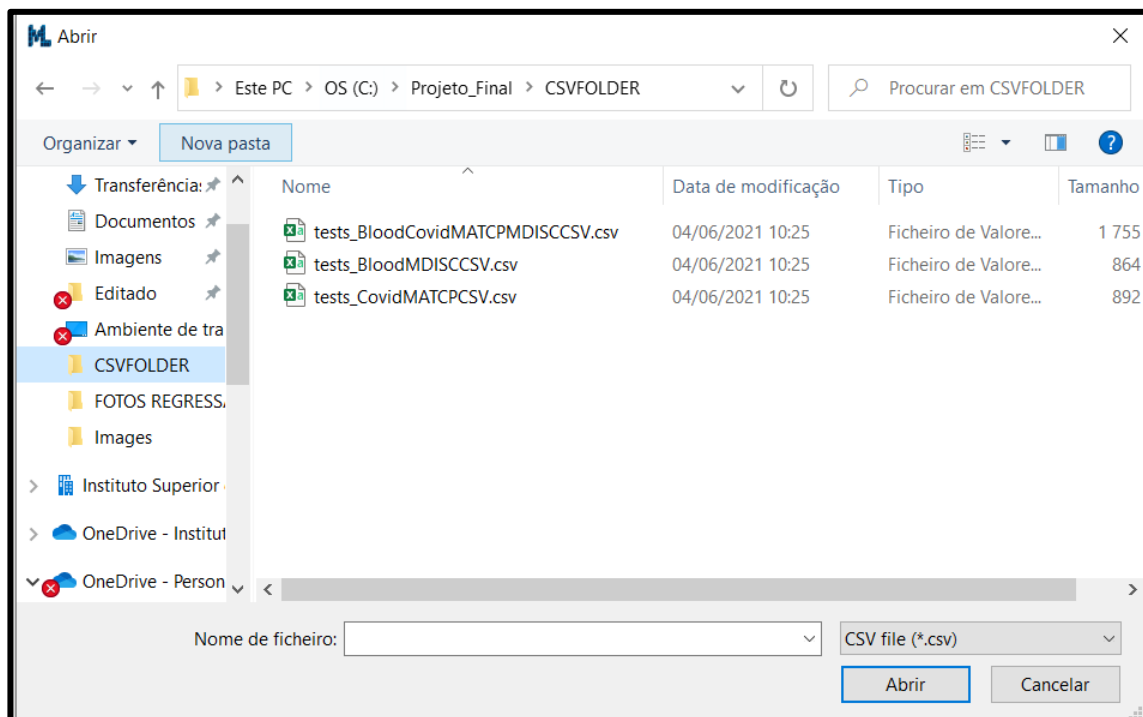
2) **Confirm the import**
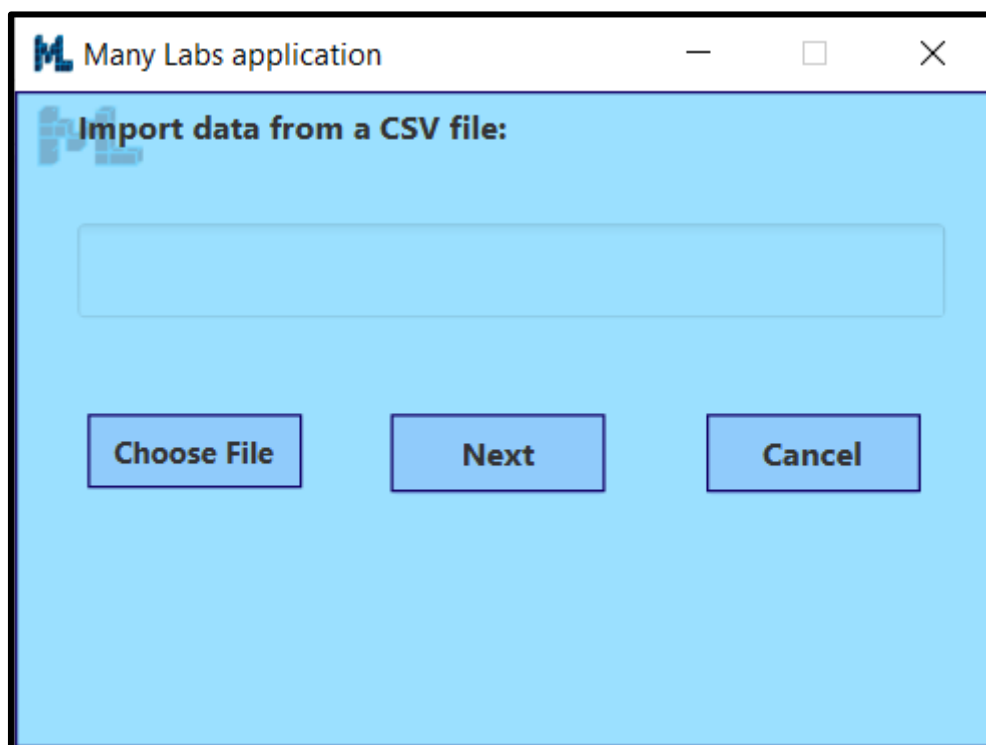
3) *After the import is successfully accomplished a table with the NHS codes belonging to the imported tests will appear.*
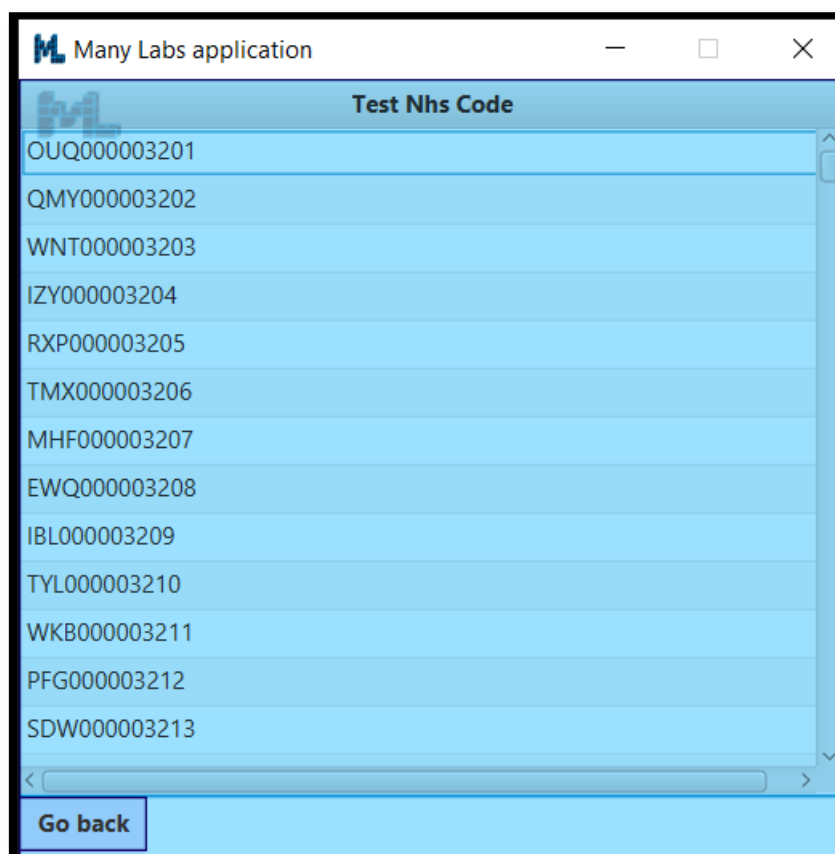
4) **(Optional) By clicking an NHS code twice a window will appear displaying the concrete information regarding the specific test.**
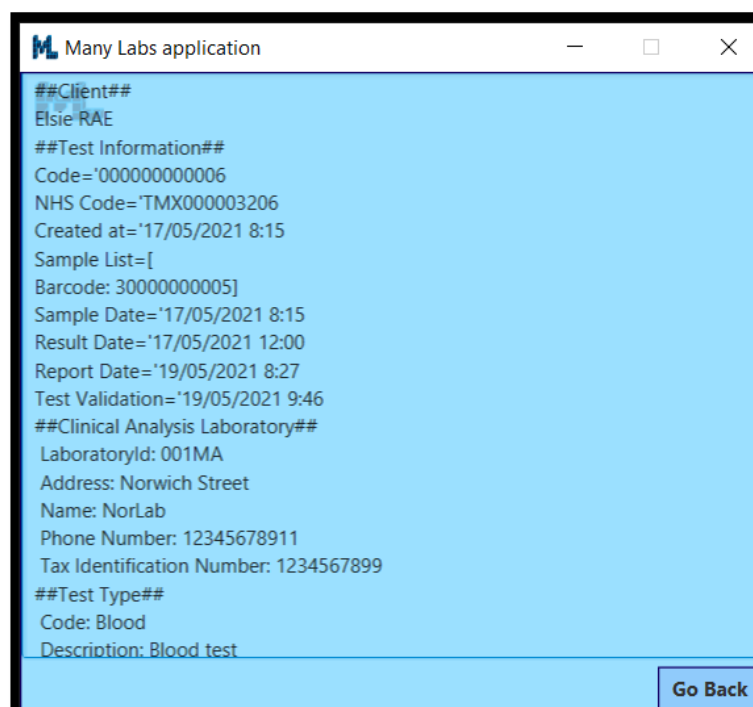
11. Automatic Functionalities

11.1. Registration Notification

After a User is registered to the Application, he will receive an e-mail that contains the information that is needed for he/she to do the login into the System.

1) An example of an email sent:

```
EMAIL
-------------------------------------------------------------------------------------
Sent By: Many Labs
Sent To: rui@hotmail.com
-------------------------------------------------------------------------------------
Message:

 Mister/Miss Rui, your registration to our application was a success.
 To do the login in the application, you must use the following data:

   - E-mail: rui@hotmail.com
   - Password: Nj54CAimmy


 The best regards from,
 Many Labs Team.
-------------------------------------------------------------------------------------
```
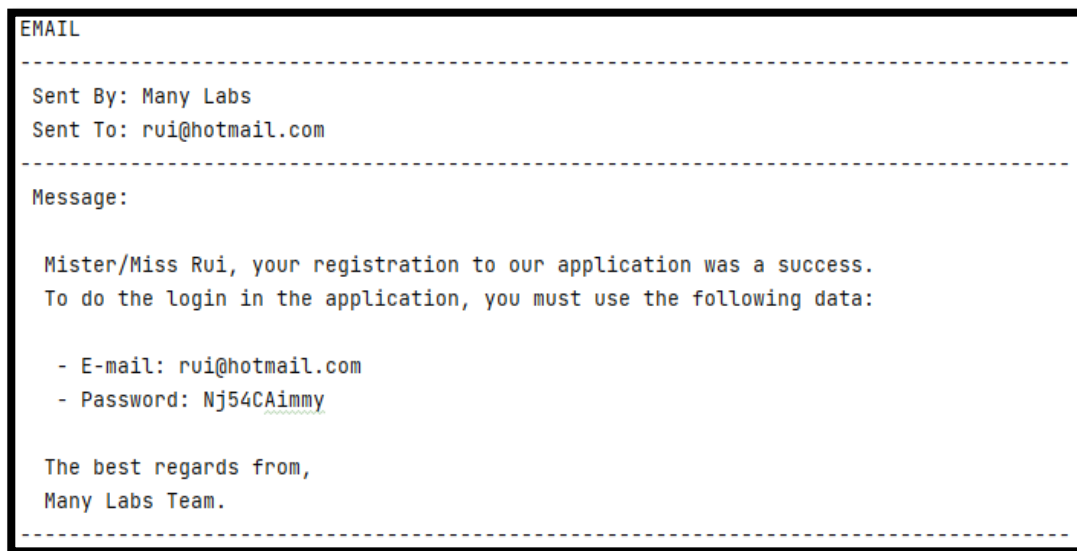
11.2. Validation Notification

After a test is validated, the Client that made the test will receive a notification that informs he/she of the test being validated. To check the results the Client needs to do the login into the Application and access the Menu.

11.3. Update Data:

When the Client finishes the update of his/her personal data, he/she will be informed of so, by a notification sent by Many Labs.

1) An example of the sent notification:

```
EMAIL
--------------------------------------------------------------------------------
Sent By: Many Labs
Sent To: GeorgiaWYNNE2155@gmail.com
--------------------------------------------------------------------------------
Message:

 Mister/Miss Georgia WYNNE,Your personal data has been updated.

 The best regards from,
 Many Labs Team.
--------------------------------------------------------------------------------
```
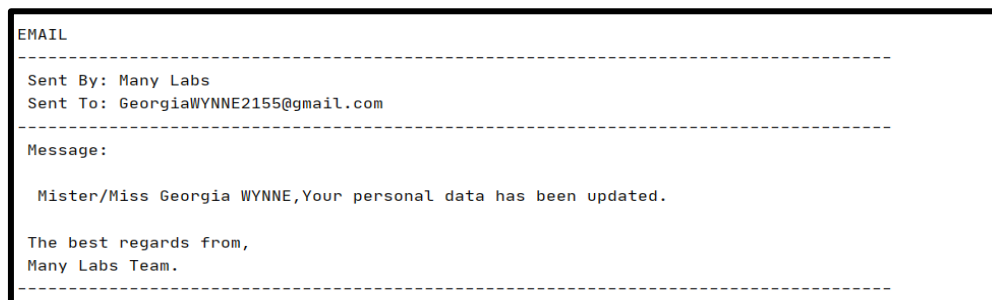
11.4. Barcode Creation:

When the Medical Laboratory Technician asks to create a certain number of samples, the system will generate a barcode (that can be accessed through the directory "BarcodeJPEG") which will have a number that will be used to identify the barcode.

1) Example of a Barcode:

11.5. Timer:

Every day, at 6:00 PM, the system will send a report of all the Sars-CoV-2 cases that were found during that same day and week to the National Healthcare Service (NHS). The User can modify the report that is sent daily to the NHS by accessing the file "regression.propreties", as represented on the image bellow:

```
fitMin=23/03/2021
fitMax=27/03/2021
weeks=1
days=6
regression=Simple Linear Regression
confidenceIntervalAlpha=0.95
hypothesisTestAlpha=0.05
```

TROUBLESHOOTING

o ***Why can't I create a new test type?***
If you are not able to create a test type, there might be three explanations:

1. There are no parameter categories in the system
2.The information inserted is wrong
3. The System has an error (try to talk with one of the Administrators).

o ***What can I do if a test does not appear for me to validate?***

If you are not able to validate, there might be two explanations:

1.There are no tests to be validated
2. The System has an error (try to talk with one of the Administrators).

o ***Why am I not able to do the login?***

If you are not able to do the login, there might be three explanations:

1. Not being registered to the System's Database.
2. The password or the e-mail are wrong.
3. The System has an error (try to talk with one of the Administrators).

o ***Why is the application not working fluidly?***

In case the application takes too long to respond to your actions, it could be because of selecting an operation that could take some time (for example, Importing Tests) or because the computer does not fulfil the System Requirements (Please check the section "INTRODUCTION – 3. System Requirements").

o ***Why are the password hidden?***

That feature gives an extra security for the User that are doing the Log In. Hide the password can protect the text introduced to be seen by another person.

o ***Why are some text camps restricted to a certain format?***

In case of some doubt introducing some data, that certain type gives a format that makes the interaction with the User more efficient.

FAQs

- o ***How can I create a new test type?***

  Login in the application as an administrator select the create a test type option, and if parameter categories are available in the system, the test type creation process should begin.

- o ***How can I validate an Existent test?***

  Login in the application as a laboratory coordinator and select the validate a test option, if there are tests available to be validated, the system will automatically show them.

- o ***Why does the Import function take so long?***

  The Import action normally does not take too much time to be finished. But it might take a long time if the computer is slow or if the import file is of a big dimension (per example 6000 tests).

- o ***Why is the Covid-19 report not being sent?***

  If the System is not sending the Covid-19 report and it did not warn you of some attributes being inserted wrong, there might be a problem with the System API that allows the sending of the report or, the selected dates do not have any Covid-19 tests performed during them.

- o ***Why are the Client chosen by a double click?***

  That feature gives the user (Laboratory coordinator) a better and easier interaction with the System, and with that function the Laboratory Coordinator have some facility to use the Application.

ANNEXES

Annex A (MATCP)

1) Simple Linear Regression

In this section of the MATCP annex, there will be an overview of the Simple Linear Regression and the calculus made to apply it to the Many Labs application.

1. *Overview of the Simple Linear Regression*

In statistics, simple linear regression is the minimum estimator square of a linear regression model with a single explanatory variable. In other words, simple linear regression fits into a straight line through the set of n-points in such a way that it makes the sum of the residual squares of the model (that is, the distances between the vertical points of the dataset and the straight line) as small as possible.

In the decision-making process it is often necessary to make predictions. It is much easier to make decisions about a given variable when it is possible to establish a relationship between this variable (the dependent variable) and another variable (independent or explanatory variable) whose behaviour is known.

In this document, the photos associated to the Simple Linear Regression are related to a model fitted between "23/03/2021" and "27/03/2021" where the independent variable is defined automatically by a method called "bestXmodel()" that is referred at the next pages:

```
-----------------NHS DAILY REPORT-----------------
The regression model fitted using data from the interval
0,87 n + -5,23
Other statistics:
 R^2 = 0,960
 R^2 (adjusted) = 1,000
 R = 0,980
```

2. Simple Linear Regression Model
2.1. Model Significance

The model significance is obtained using the variance analysis (ANOVA table) that permits the analysis of:

- Total variation of the observations (total variation)
- Total variation of the dependent variable (regression variation)
- Variation that is not explained by the model (residual variation)

The team used various methods that permit the calculus of all the values that are talked about above. The obtained table represents the values that were gotten by those methods (for the regression whose values fit the "23/03/2021" to "27/03/2021"):

```
Significance model with Anova
 H0: b=0  H1:b<>0
                df  SS       MS           F
 Regression    1   43,010   43,010       72,075
 Residual      3.0 1,790    0,597
 Total         4.0 44,800
 Decision: f
 0 > f0,050,(1,3)=10,128
  Reject H0
 The regression model is significant.
```

2.2. Hypothesis Tests for Model Coefficients

A hypothesis test is a test that permits the testing of the regression coefficients.

For the Simple Linear Regression can be made for the parameter a or b, but the way that we calculate the T_a and the T_b are different:

$$T_a = \frac{\hat{a} - a_0}{S\sqrt{\frac{1}{n} + \frac{(\bar{x})^2}{S_{xx}}}} \sim t_{n-2}$$

$$T_b = \frac{\hat{b} - b_0}{S / \sqrt{S_{xx}}} \sim t_{n-2}$$

If the T_x (T_x is being used to represent both T_a and T_b) value is bigger than the critical value, the hypothesis should be rejected:

$$|t_0| > t_{\frac{1-\alpha}{2}}, n - 2$$

But what does this mean? The rejection of a hypothesis signifies that the tested coefficient could be "eliminated".

The team created two separate methods to make the calculus of T_a and T_b, has represent in the next image:

```java
public String testHypothesisForB(double alphaTD){
    boolean rejectB;

    int n = this.y.length;
    int degreesOfFreedom = n - 2;

    double b0 = 0;
    this.sSquared= calculateSSquared(degreesOfFreedom);

    TDistribution tStudent = new TDistribution(degreesOfFreedom);
    double critTD;
    double alpha = (1+(1-alphaTD))/2;

    if(alpha > 0.5) {
        critTD = tStudent.inverseCumulativeProbability(alpha);
    }
    else {
        critTD = tStudent.inverseCumulativeProbability( p: 1 - alpha);
    }
    rejectB = calculateT0b(critTD, b0);
    StringBuilder rejectionB = new StringBuilder();

    if(rejectB){
        rejectionB.append("Reject H0(b=0)");
    }
    else{
        rejectionB.append("Do not reject H0(b=0)");
    }
    return rejectionB.toString();
}
```

```java
public String testHypothesisForA(double alphaTD){
    boolean rejectA;
    int n = this.y.length;
    int degreesOfFreedom = n - 2;

    double a0 = 0;

    this.sSquared= calculateSSquared(degreesOfFreedom);

    TDistribution tStudent = new TDistribution(degreesOfFreedom);
    double critTD;
    double alpha = (1+(1-alphaTD))/2;
    if(alphaTD > 0.5) {
        critTD = tStudent.inverseCumulativeProbability(alpha);
    }
    else {
        critTD = tStudent.inverseCumulativeProbability( p: 1 - alpha);
    }
    rejectA = calculateT0a(critTD, a0, n);
    StringBuilder rejectionA = new StringBuilder();

    if(rejectA){
        rejectionA.append("Reject H0(a=0)");
    }
    else{
        rejectionA.append("Do not reject H0(a=0)");
    }
    return rejectionA.toString();
}
```

To confirm the methods the team calculated the values for the values 1% and 5%, the values that were gotten by the team are presented on the images bellow:

1) **For one percent**

```
Hypothesis tests for regression coefficients
H0:b=0 (a=0) H1: b<>0 (a<>0)
t_obsA = -0,475
t_obsB = 7,462
Decision:
Do not reject H0(a=0)
Reject H0(b=0)
```

2) For five percent

```
Hypothesis tests for regression coefficients
H0:b=0 (a=0) H1: b<>0 (a<>0)
t_obsA = -0,475
t_obsB = 7,462
Decision:
Do not reject H0(a=0)
Reject H0(b=0)
```

2.3. Confidence Intervals for Prediction Values

The use of confidence intervals allows us to predict the value of positive Covid-19 cases for each day or week. To do so, the formula to be used was:

To do this calculus the team implemented the next method, which allows the system to predict the values that will be sent on the report:

To test the used algorithm, the team made two tests using the next confidence values:

1) Confidence Interval of 90 percent

Date	Number of OBSERVED positive cases	Number of ESTIMATED positive cases	90.0% intervals
27/03/2021	74	74,55	72,17-76,92
26/03/2021	76	75,41	73,10-77,72
25/03/2021	78	77,15	74,88-79,42
24/03/2021	74	74,55	72,17-76,92
23/03/2021	82	82,35	79,49-85,21
22/03/2021	84	89,29	84,74-93,83
Week	Number of OBSERVED positive cases	Number of ESTIMATED positive cases	90.0% intervals
1	468	499,44	366,12-632,76

2) Confidence Interval of 95 percent

Date	Number of OBSERVED positive cases	Number of ESTIMATED positive cases	95.0% intervals
27/03/2021	74	74,55	71,33-77,76
26/03/2021	76	75,41	72,29-78,53
25/03/2021	78	77,15	74,08-80,21
24/03/2021	74	74,55	71,33-77,76
23/03/2021	82	82,35	78,48-86,22
22/03/2021	84	89,29	83,14-95,43
Week	Number of OBSERVED positive cases	Number of ESTIMATED positive cases	95.0% intervals
1	468	499,44	319,16-679,72

2) Multiple Linear Regression

In this section of the MATCP annex, there will be an overview of the Multiple Linear Regression and the calculus made to apply it to the Many Labs application.

1. Overview of Multiple Linear Regression

Often a single predictor variable will not be able to explain everything about the response variable. For example, the income of a given person (response variable) is influenced by several variables, such as gender, age, schooling, among others. So, we need to perform a multiple linear regression.

In the regression analysis we found situations with more than one explanatory variable. This regression model is named a multiple regression model (RLM). The dependent variable or Y response may be related to k explanatory or independent variables.

In this document, the photos associated to the Multiple Linear Regression are related to a model fitted between "23/03/2021" and "27/03/2021" where the independent variables are the number of Covid-19 tests and the mean age of the person who did the test for each fit day:

```
----------------NHS DAILY REPORT----------------
The regression model fitted using data from the interval
 11,34 + (-0,31) x1 + (0,92) x2
 Other statistics:
 R^2 = 0,990
 R^2 (adjusted) = 0,979
```

2. Multiple Linear Regression Model
2.1. Model Significance

The model significance is obtained using the variance analysis (ANOVA table) that permits the analysis of:

- Total variation of the observations (total variation)
- Total variation of the dependent variable (regression variation)
- Variation that is not explained by the model (residual variation)

The team used various methods that permit the calculus of all the values that are talked about above. The obtained table represents the values that were gotten by those methods (for the regression whose values fit the interval "23/03/2021" to "27/03/2021"):

```
Significance model with Anova
 H0: beta1=beta2=0  H1:betaj<>0
                df  SS       MS          F
 Regression     2   44,340   22,170      96,491
 Residual       2   0,460    0,230
 Total          4   44,800
 Decision: f
 0 > f0,050,(2,2)=19,000
  Reject H0
 The regression model is significant.
```

2.2. Hypothesis Tests for Model Coefficients

A hypothesis test is a test that permits the testing of the regression coefficients. This test is made through the calculus of the T_0 value and by comparing it to the critical value. To calculate T_0:

$$T_0 = \frac{\hat{\beta}_j}{\sqrt{\hat{\sigma}^2 Cjj}}$$

If the T_0 value is bigger than the critical value, the hypothesis should be rejected:

$$|t_0| > t_{\frac{1-\alpha}{2}}, n - (k + 1)$$

But what does this mean? The rejection of a hypothesis signifies that the tested coefficient could be "eliminated".For the Multiple Linear Regression, the team made two methods that allow the Application to do a hypothesis test over the two betas (β_1 and β_2). The two methods obtain the T_0 value of the two betas (obtained using the T Student function) and check if they are within the critical interval, if so, the application will obtain the result that represents the rejection of the hypothesis (the hypothesis is always, $\beta = 0$). The used method is represented in the next image:

```java
/**
 * Allows the System to do the hypothesis test for Beta 1.
 *
 * @param alphaValue Significance Value to be used.
 * @return String that represents if Beta 1 should be rejected or not.
 */
public String hypothesisTestForBeta1 (double alphaValue){
    double beta = calculateRegression()[1][0];

    double cjj = getCjj( position: 1);

    double standardErrorAverageSquare = quadraticAverageSSE();
    double multiply = cjj * standardErrorAverageSquare;
    double squareRoot;
    if(multiply > 0) {
        squareRoot = Math.sqrt(multiply);
    }else{
        squareRoot = Math.sqrt(-multiply);
    }
    this.t01= beta/squareRoot;

    double valueOfTStudent = calculateTStudent(alphaValue);

    if(isOnCriticalInterval(valueOfTStudent, t01)){
        return "Reject H0 (beta1 = 0)";
    }
    else{
        return "Do not reject H0 (beta1 = 0)";
    }
}
```

The next images will represent the obtained values for one and five percent respectively (the interval used was from "23/03/2021" to "27/03/2021"):

1) **For one percent**

```
Hypothesis tests for regression coefficients
H0:beta1=0 (beta2=0) H1: beta1<>0 (beta2<>0)
t_obs1 = -0,331
t_obs2 = 1,986
Decision:
Do not reject H0 (beta1 = 0)
Do not reject H0 (beta2 = 0)
```

2) **For five percent**

```
Hypothesis tests for regression coefficients
H0:beta1=0 (beta2=0) H1: beta1<>0 (beta2<>0)
t_obs1 = -0,331
t_obs2 = 1,986
Decision:
Do not reject H0 (beta1 = 0)
Do not reject H0 (beta2 = 0)
```

2.3. Confidence Intervals for Prediction Values

To calculate the prediction interval of some action (in this case, number of positive Covid-19 cases), it is needed to use the next formula:

$$]\hat{y}_0 - t_{\frac{1-a}{2}[n-(k+1)]}\sqrt{\sigma^2(1 + x_0^T C x_0)} \; ; \; \hat{y}_0 + t_{\frac{1-a}{2}[n-(k+1)]}\sqrt{\sigma^2(1 + x_0^T C x_0)}[$$

To do this the team utilized a method that calculates those values:

```java
public String predictionConfidenceInterval (double [][] xZero , double alphaTD){
    double [][] xZeroTransposed = MatrixCalculus.calculateTransposeMatrix(xZero);
    double [][] beta = calculateRegression();
    double[][] y0Matrix = MatrixCalculus.multiplyMatrix(xZeroTransposed,beta);
    double y0Value= MatrixCalculus.sumMatrixValues(y0Matrix);

    TDistribution td= new TDistribution(getDegreeFreedomSSE());
    double critTD;
    double alpha= (1+alphaTD)/2;
    if(alpha> 0.5) {
        critTD = td.inverseCumulativeProbability(alpha);
    }
    else {
        critTD = td.inverseCumulativeProbability( p: 1 - alpha);
    }
    double sigmaSquared=quadraticAverageSSE();
    double[][] C= getC();
    double[][] x0tByC=MatrixCalculus.multiplyMatrix(xZeroTransposed,C);
    double[][] x0tByCbyX0=MatrixCalculus.multiplyMatrix(x0tByC,xZero);
    double insideSqrtPartOne = (MatrixCalculus.sumMatrixValues(x0tByCbyX0) +1);
    double insideSqrt= insideSqrtPartOne * sigmaSquared;
    double sqrt = Math.sqrt(insideSqrt);
    double delta = critTD * sqrt;
    double min = y0Value - delta;
    double max = y0Value + delta;
    return String.format("%.2f-%.2f",min,max);
}
```

To confirm the made method, the team made some tests for two confidence values (90% and 95%, the regression model had a fit between "23/03/2021" and "27/03/2021"). The prediction was made considering six historical points:

1) Confidence Interval of 90 percent

```
Date           Number of OBSERVED positive cases    Number of ESTIMATED positive cases    90.0% intervals
27/03/2021            74                                    74,56                          72,95-76,16
26/03/2021            76                                    75,84                          74,19-77,48
25/03/2021            78                                    77,79                          76,07-79,52
24/03/2021            74                                    73,73                          71,84-75,62
23/03/2021            82                                    82,09                          80,12-84,05
22/03/2021            84                                    88,72                          85,57-91,87

Week           Number of OBSERVED positive cases    Number of ESTIMATED positive cases    90.0% intervals
1                   468                                    527,03                         430,81-623,25
```

2) Confidence Interval of 95 percent

```
Date           Number of OBSERVED positive cases    Number of ESTIMATED positive cases    95.0% intervals
27/03/2021            74                                    74,56                          72,19-76,92
26/03/2021            76                                    75,84                          73,41-78,26
25/03/2021            78                                    77,79                          75,25-80,33
24/03/2021            74                                    73,73                          70,95-76,51
23/03/2021            82                                    82,09                          79,19-84,98
22/03/2021            84                                    88,72                          84,07-93,36

Week           Number of OBSERVED positive cases    Number of ESTIMATED positive cases    95.0% intervals
1                   468                                    527,03                         385,24-668,82
```

3) Best Model

In this section, there will be explanations of what the best Independent Variable for the Simple Linear Regression is and of the best Regression Model to be used on the NHS Report to be sent.

1. Best Independent Variable for Simple Linear Regression

There are several ways to check what the best independent variable for the Simple Linear Regression, but the team decided to do this confirmation by using the R^2 by ANOVA model.

This is done by selecting the independent variable that has got the highest R^2. To do so, it is necessary to calculate R^2 by using the following formula:

$$R^2 = \frac{MSS}{TSS} = \frac{(TSS - RSS)}{TSS}$$

The formula above obtains the value of R^2, by dividing the model sum of squares (MSS, which value is obtained by the sum of the squares of the prediction from the Simple Linear Regression, TSS, minus the residual sum of the squares for that variable, RSS) by the sum of squares of the prediction from the Simple Linear Regression (TSS).

To do this calculus on the application, the utilized method/algorithm is the one represented on the image bellow:

```java
/**
 * Method to evaluate the best independent variable for the Simple linear Regression.
 *
 * @param vec1 vector that will take the Mean age data.
 * @param vec2 vector that will take the Number of Tests data.
 * @param y the dependent variable.
 * @return A String with the best model name.
 */
public static String bestXForModel(double[] vec1, double[] vec2, double[] y){
    SimpleLinearRegressionAlgorithm vec1Simple = new SimpleLinearRegressionAlgorithm(vec1,y);
    SimpleLinearRegressionAlgorithm vec2Simple = new SimpleLinearRegressionAlgorithm(vec2,y);
    double r2forVec1= vec1Simple.R2byAnova();
    double r2forVec2= vec2Simple.R2byAnova();
    if (r2forVec1 > r2forVec2) {
        return Constants.X_VARIABLE_AGE;
    } else {
        return Constants.X_VARIABLE_TESTS;
    }
}
public static boolean isFullOfZeros(List<Integer> list){
    for(Integer i:list){
        if(i!=0){
            return false;
        }
    }
    return true;
}
```

2. Comparing the Predictions (Best Regression Model)

To do the predictions comparison is going to be generated two regressions and check their predictions for Covid-19 cases, and the regression with the values more closers to the real values, is the one that is going to be defined in the configuration file of the application.

To create the model is going to be used an interval of values between "23/03/2021" and "27/03/2021", and the predictions are for 6 historical points with available tests.

To decide de regression, it is needed to sum the positive "Observed" of each day, and then sum the "Estimated" covid positive values for the two regressions. With the obtained values at the regressions, is needed to subtract the sum of the positive "Observed" cases. Then the regression with the minor value is the one that is going to be predefined at the configuration file.

As the Many Labs does not work at Sundays, a week is going to be constituted by 6 days.

So, with this is possible to simplify the calculus to obtain the best prediction model:

To the number of "Estimated" cases of the week, is only needed to subtract the "Observed" values, and, then the regression with the minor result is the one that is going to be predefined at the configuration file.

With the values of the tables of the Confidence interval values:

Calculus:

1.Simple Linear Regression:

 Result: 499,44 - 468 = 31,44

 2.Multiple Linear Regression:

 Result: 527,03 – 468 = 59,03

With the obtained results the Regression that is going to be defined at the configuration file, is the Simple Linear Regression, due to having the closer to the "Observed values".

Annex B (MDISC)

1. Sorting Client by name or TIN
1.1 Introduction

This algorithm (Bubble Sort) is one of the simplest sorting algorithms, but not more efficient. Sorts of elements in ascending order by simply comparing adjacent values two to two and placing them in ascending order in case they are not.

SortingAlgorithm1 Class

procedure Bubble_Sort(a[1], a[2], ..., a[n]: real)

for i:= 1 to n-1

    for j:= 1 to n-i

        if a[j] > a[j+1]

            then swap a[j] and a[j+1]

This algorithm (Insertion Sort or insertion ordering) is an algorithm that traverses a vector of elements from left to right and as it advances it is ordering the elements to the left. The operation of the algorithm consists of each step from the second element selecting the next item of the sequence and placing it in the appropriate location according to the ordering criterion.

SortingAlgorithm2 Class

procedure Insert_Sort(a[1], a[2], ..., a[n]: real)

for i:= 1 to n

    int x = i

    while (a[x] < a[x - 1])

        then swap a[x-1] and a[x]

            if x > 1

                x—

return a[]

1.2 Runtime tests for inputs of varying sizes

Values: Left side - Insertion Sort ; Right side - Bubble Sort

To show the run time of the different algorithms was made graphs for the various algorithms. The input size of the arrays tested was done with a 3000 $\times x$ ($\sum_{x=1}^{20} x$) that will be used for variable x for all graphics.

Values: Left side - Insertion Sort; Right side - Bubble Sort

n elements	time in milliseconds		n elements	time in milliseconds	
3000	734,2904		3000	1054,9859	
6000	1019,5862		6000	1655,2386	
9000	3161,8039		9000	4356,2211	
12000	3316,9609		12000	5436,0567	
15000	5485,1641		15000	9660,6572	
18000	7957,0093		18000	12151,5689	
21000	10974,927		21000	21232,9669	
24000	11877,4265		24000	25799,2057	
27000	15227,4083		27000	31579,6584	
30000	18017,22899		30000	37699,8388	
33000	21602,5799		33000	44747,519	
36000	27046,727		36000	59321,473	
39000	31989,7045		39000	70971,1553	
42000	40251,6911		42000	90143,986	
45000	50522,375		45000	114573,71	
48000	58531,1565		48000	148406,7704	
51000	69758,2644		51000	181002,6709	
54000	84673,7024		54000	205759,1236	
57000	96089,8689		57000	230427,3583	
60000	113434,4565		60000	275867,997	

As you can see the graphs of the Insertion Sort and Bubble Sort Algorithms confirm that these graphics have a n^2 line which means that the Big-O analysis is in correspondence with the graphs displayed above.

Both the bubble sort algorithm and the insertion sort both possess a worst-case complexity of $O(n^2)$. But by analyzing the graph we can conclude that at the same number of elements in an array the insertion sort has a better execution time mostly because the insertion sort has a while loop that depends on a condition to be executed while the bubble sort possesses a for loop which is executed a set number of times and therefore creating the difference in execution times.

1.3 Worst-case time complexity analysis

The worst-case complexity (usually denoted in asymptotic notation) measures the resources that an algorithm requires given an input of arbitrary size (denoted as n or N). It gives an upper bound on the resources required by the algorithm.

In the case of running time, the worst-case time complexity indicates the longest running time performed by an algorithm given any input of size n, and thus guarantees that the algorithm will finish in the indicated period.

To analyze the worst-case time complexity is used a notation called Big-O. That notation can give the time of the worst-case time-complexity for different algorithms. The order of growth (e.g., linear, logarithmic, exponential) of the worst-case complexity is commonly used to compare the efficiency of two algorithms.

Big-O analyze (Sorting Algorithm 1)

procedure Bubble_Sort(a[1], a[2], ..., a[n]: real)

for i:= 1 to n-1	**(n-1) +1 A ou I + (n -1)+1 C**
for j:= 1 to n-i	$\sum_{i=1}^{n-1}(n-i)$ +(n-1) =*$\frac{n^2}{2} - \frac{n}{2}$+(n-1) A ou I + $\frac{n^2}{2} - \frac{n}{2}$+(n-1) C
if a[j] > a[j+1]	$\frac{n^2}{2} - \frac{n}{2}$ C
then swap a[j] and a[j+1]	≤$\frac{n^2}{2} - \frac{n}{2}$ Op
return a[]	**1 R**

* $\sum_{i=1}^{n-1}(n-i) = \sum_{i=1}^{n-1} n - \sum_{i=1}^{n-1} i = n \times (n-1) - \frac{1+(n-1)}{2} \times (n-1) = \frac{n^2}{2} - \frac{n}{2}$

Complexity of worst-case:

$$O(2 \times n) + O\left(2 \times (\frac{n^2}{2} - \frac{n}{2} + n - 1)\right) + O\left(\frac{n^2}{2} - \frac{n}{2}\right) + O\left(\frac{n^2}{2} - \frac{n}{2}\right) + O(1)$$
$$= \boldsymbol{O(n^2)}$$

Big-O analyze (Sorting Algorithm 2)

procedure Insertion_Sort(a[1], a[2], ..., a[n]: real)

for i:= 2 to n	**n Aoul + n C**
int x = i;	**n-1 A**
while (a[x] < a[x - 1])	$\sum_{i=1}^{n-1} i$ =≤*$\frac{n^2}{2} - \frac{n}{2}$ C

swap a[x-1] and a[x]	$\leq \frac{n^2}{2} - \frac{n}{2}$ **Op**
if x > 1	$\leq \frac{n^2}{2} - \frac{n}{2}$ **C**
x--	$\leq \frac{n^2}{2} - \frac{n}{2}$ **I**
return a[]	**1 R**

$$\sum_{i=1}^{n-1}(n-i) = \sum_{i=1}^{n-1}n - \sum_{i=1}^{n-1}i = n \times (n-1) - \frac{1+(n-1)}{2} \times (n-1) = \frac{n^2}{2} - \frac{n}{2}$$

Complexity of worst-case:

$$O(2 \times n) + O(n-1) + O\left(\frac{n^2}{2} - \frac{n}{2}\right) + O\left(\frac{n^2}{2} - \frac{n}{2}\right) + O\left(\frac{n^2}{2} - \frac{n}{2}\right)$$

$$+ O\left(\frac{n^2}{2} - \frac{n}{2}\right) + O(1) = \boldsymbol{O(n^2)}$$

2. *Evaluation of the effectiveness of the company's response*

2.1 Introduction

Many labs to determine the effectiveness of the company's response to new covid tests needs an algorithm that will be able to determine the interval where the company´s response was more efficient. The brute force algorithm gives the larger subsequential array of numbers simply by going through all the existing subsequences and returns the subsequence with the greatest sum, which in relation with the problem equates to the interval of time where many labs was more efficient.

```
BruteForceAlgorithm class
procedure Brute_Force_Algorithm(a[1], a[2], …, a[n]: real)
    int maxSoFar = 0
    int startMaxSoFar = 0
    int endMaxSoFar = 0
    int sum = 0
    for i:= 1 to n
            for j:= i to n
             sum = sum + a[j]
                    if maxSoFar < sum
                            maxSoFar = sum
                            startMaxSoFar = i
                            endMaxSoFar = j
            sum = 0
    return a[]
```

Many labs to determine the effectiveness of the company's response to new covid tests needs an algorithm that will be able to determine the interval where the company´s response was more efficient. The brute force algorithm gives the larger subsequential array of numbers simply by going through all the existing subsequences and returns the subsequence with the greatest sum, which in relation with the problem equates to the interval of time where many labs was more efficient.
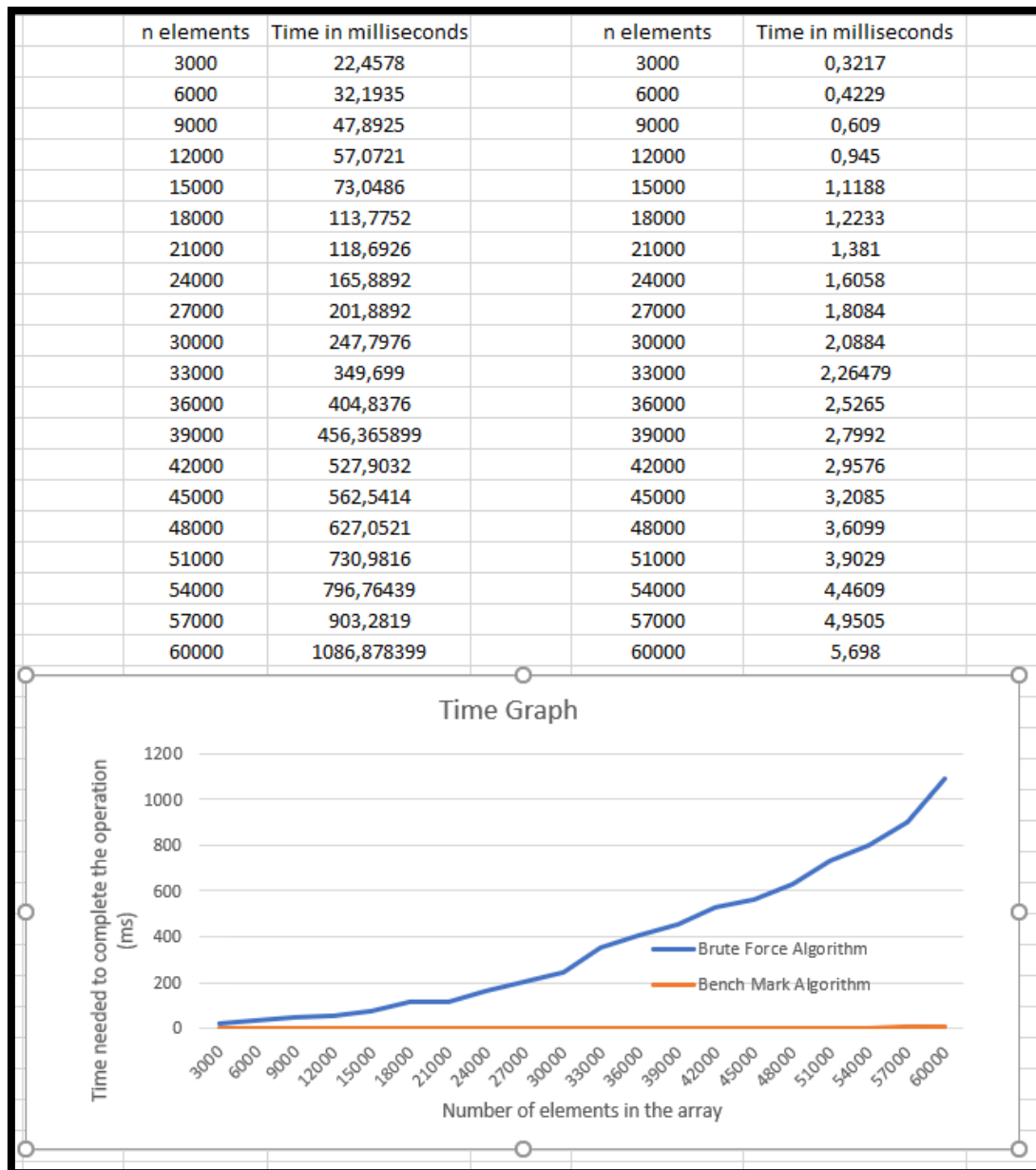
```
BruteForceAlgorithm class
procedure Brute_Force_Algorithm(a[1], a[2], ..., a[n]: real)
    int maxSoFar = 0
    int startMaxSoFar = 0
    int endMaxSoFar = 0
    int sum = 0
    for i:= 1 to n
            for j:= i to n
             sum = sum + a[j]
                    if maxSoFar < sum
                            maxSoFar = sum
                            startMaxSoFar = i
                            endMaxSoFar = j
            sum = 0
    return a[]
```

2.2 Runtime tests for inputs of varying sizes

For varied-length time intervals was made graphs for the various algorithms. The input size of the arrays tested was done with a 3000 × x ($\sum_{x=1}^{20} x$) that will be used for variable x for all graphics.

	n elements	Time in milliseconds		n elements	Time in milliseconds	
	3000	22,4578		3000	0,3217	
	6000	32,1935		6000	0,4229	
	9000	47,8925		9000	0,609	
	12000	57,0721		12000	0,945	
	15000	73,0486		15000	1,1188	
	18000	113,7752		18000	1,2233	
	21000	118,6926		21000	1,381	
	24000	165,8892		24000	1,6058	
	27000	201,8892		27000	1,8084	
	30000	247,7976		30000	2,0884	
	33000	349,699		33000	2,26479	
	36000	404,8376		36000	2,5265	
	39000	456,365899		39000	2,7992	
	42000	527,9032		42000	2,9576	
	45000	562,5414		45000	3,2085	
	48000	627,0521		48000	3,6099	
	51000	730,9816		51000	3,9029	
	54000	796,76439		54000	4,4609	
	57000	903,2819		57000	4,9505	
	60000	1086,878399		60000	5,698	

As you can see in the graph pertaining to the Brute Force Algorithm has a n^2 line which means that the Big-O analysis is in correspondence with the graph displayed above.

With this graph we can easily spot the difference between the execution times for the same number of elements in the array between the two algorithms, that difference being that the benchmark algorithm is much more optimized having a lesser execution time than the brute force algorithm that possesses a worst-case time complexity O (n^2).

2.3 Worst-case time complexity analysis

(Analysis of the time complexity in the worst case of the developed brute-force algorithm, accurately explained.)

procedure Brute_Force_Algorithm(a[1], a[2], …, a[n]: real)

int maxSoFar = 0	**1 A**
int startMaxSoFar = 0	**1 A**
int endMaxSoFar = 0	**1 A**
int sum = 0	**1 A**
for i:= 1 to n	**n+1 A ou I + n+1 C**
for j:= i to n	$\sum_{i=1}^{n}(n-i)+(n)=* \frac{n^2}{2}+\frac{n}{2}+n$ **A ou I** $+\frac{n^2}{2}+\frac{n}{2}+n$ **C**
sum = sum + a[j]	$\frac{n^2}{2}+\frac{n}{2}$ **A e Op**
if maxSoFar < sum	$\frac{n^2}{2}+\frac{n}{2}$ **C**
maxSoFar = sum	$\leq \frac{n^2}{2}+\frac{n}{2}$ **A**
startMaxSoFar = I	$\leq \frac{n^2}{2}+\frac{n}{2}$ **A**
endMaxSoFar = j	$\leq \frac{n^2}{2}+\frac{n}{2}$ **A**
sum = 0	**n A**
return a[]	**1 R**

$* \sum_{i=1}^{n}(n-i) = \sum_{i=1}^{n} n - \sum_{i=1}^{n} i = n \times (n+1) - (\frac{n+1}{2} \times n \ )$

$$= n^2 + n - \frac{n^2+n}{2} = \frac{n^2}{2}+\frac{n}{2}$$

Complexity of worst-case:

$$O(1) + O(1) + O(1) + O(1) + O(2 \times (n+1)) + O\left(2 \times (\frac{n^2}{2}+\frac{n}{2}+n)\right)$$
$$+ O\left(\frac{n^2}{2}+\frac{n}{2}\right) + \left(\frac{n^2}{2}+\frac{n}{2}\right) + \left(\frac{n^2}{2}+\frac{n}{2}\right) + \left(\frac{n^2}{2}+\frac{n}{2}\right) + \left(\frac{n^2}{2}+\frac{n}{2}\right) + O(n)$$
$$+ O(1) = \boldsymbol{O(n^2)}$$

GLOSSARY

Barcode	It allows the identification of a product through a code made up of bars.
Benchmark Algorithm	It refers to a standard algorithm that will be compared with another algorithm, allowing the analysis of its performance.
Brute-Force Algorithm	It refers to an algorithm that consists of enumerating all possible candidates for the solution and checking whether each candidate satisfies the problem's statement.
Blood Test	It refers to a type of test that analyzes the composition of the blood.
Category	It is used to refer to a group of Test parameters.
Chemical Analysis	It refers to a analysis whose objective is to analyze a Sample and arrive to a result, made in *Chemical Laboratory*.
Chemical Laboratory	Laboratory where the analysis of the Sample and creation of the Test Report is performed.
Citizen Card Number	Sixteen-digit number unique to a person in the UK.
Client	Person requesting a Test.
Clinical Analysis	It refers to a analysis whose objective is to collect the Samples for a Test, made in *Clinical Analysis Laboratory*.
Clinical Analysis Laboratory	Laboratory responsible for the collection of samples and Client interaction.
COVID-19 Test	It refers to a type of test that analyzes if a person tests positive or negative for COVID-19.
Efficiency Algorithm	It refers to the algorithm that compares the number of test analyses with the number of tests requested.
External Module	It refers to a module used in the development of the application, but not developed by the team.
Hemogram	It refers to a type of blood Test.
Independent Variable	It refers to the variable used in the creation of the regression model (mean age,number of total cases)
Laboratory Coordinator	It is used to reference the person that validates the results of the tests and the Test Report before becoming available in the system.
Linear Regression Algorithm	It refers to an algorithm capable of predicting COVID-19 cases using some previous parameters.
Many Labs	Company that wants an application to manage the tests and the procedures associated with them.
Medical Lab Technician	Person that records the Sample collected and associates it with the Client/Test.

National Healthcare Service	It refers to a service that take care about the Health of English people.
National Healthcare Service Number	Ten-digit number unique to a person in England.
Number of historical points	It refers to the number of days to be used in the creation of the regression model
NHS	Acronym for *National Healthcare Service*.
NHS Report	It refers to the report of COVID-19 cases found by Many Labs and its predictions for the future cases.
Parameter	It refers to a criteria evaluated in a Test.
Password	Passcode needed for authentication in the application.
Receptionist	It is used to reference the person that makes the client entries and registers the Test to be performed.
Sample	It refers to what is collected by the Clinical Analysis Laboratory and to what will be tested by the Chemical Laboratory.
Sorting Algorithm	It refers to an algorithm that changes the position of the elements of a list to make them follow a certain order.
Specialist Doctor	Person responsible for doing the analysis of the Test results and making a diagnosis/writing a report.
Tax Identification Number	Ten-digit number unique to a person in England.
Test	It refers to a clinical analysis test.
Test Type	It refers to a type of clinical analysis test.
Test Report	It refers to the report made by the Specialist Doctor about the Test result.
Test Result	It refers to the result of the Test, made by the Specialist Doctor.

CREDITS

The Many Labs Application was developed by a small team of four elements, during a time span of three months. The involved members were:

- Luís Ribeiro (1201184@isep.ipp.pt)
- Pedro Graça (1201188@isep.ipp.pt)
- Miguel Ramos (1201247@isep.ipp.pt)
- André Soares (1201314@isep.ipp.pt)