User Manual

Group 12- The Penguins
Guilherme Coelho (1211154)
Guilherme Melo (1211008)
Jonas Antunes (1181478)
Pedro Gomes (1211690)
Rui Franco (1191038)

Professors:
LAPR2: Sandra Luna
Carlos Ferreira
MDISC: Luís Roque
MATCP: Teresa Ferro
ESOFT: António Pereira
PPROG: Hugo Pinto

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Instituto Superior de Engenharia do Porto

DEPARTAMENTO DE ENGENHARIA INFORMÁTICA
Instituto Superior de Engenharia do Porto

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1. Introduction

1.1. Purpose and scope

Welcome to the Penguins Application User Manual. The purpose of this Manual is to provide documentation for users such as HealthCare Workers and Administrators.

1.2. System Overview

This application is designed and structured to help HealthCare Systems, Workers and SNS users with organizing Vaccination Centers and Health Care Centers for Vaccination.

As an SNS user, you can:

- Schedule a vaccine.

As an administrator, you can:

- Register Vaccination Centers;
- Register Health Care Centers;
- Register Employees;
- Register the Vaccine;
- Register the Vaccine Type.
- List employees by role.
- Export SMS notifications.
- Serialize the data.

As a receptionist, you can:

- Register a user through their HealthCare Number and other personal information (i.e. Citizen Card Number, Name, Age);
- Schedule a vaccination at your Working Center;
- Register the arrival of scheduled users to the Vaccination Center or HealthCare Center.

As a nurse, you can:

- Consult the users in the Waiting Room;
- Record adverse reactions of Users to the Vaccine;
- Record the administration of a Vaccine.

As a center coordinator, you can:

- Check and export vaccination statistics;
- Analyze the performance of a chosen center;
- Import data from a legacy system.
- Sort data from a legacy system.

1.3. System Requirements

- RAM: At least 128 MB.
- Disk Space: 10.3 MB
- Processor: Minimum Pentium 2 MHz Processor
-

1.4. Software Installation

1. Open the terminal of the computer
2. Write “java -jar ”
3. Drag .jar file of the app to the terminal.

2. Features

2.1. Administrator Menu

2.1.1. Register Vaccination Center

To register a vaccination center, the user should:

1. Specify the vaccination center’s type (community mass vaccination center or health care center).
2. Insert the vaccination center’s name, address, phone number, email address, fax number, website address, opening hours, opening minutes, closing hours, closing minutes, slot duration, and maximum number of vaccines per slot (any of these parameters cannot be null or empty and the phone number should be numeric and have exactly 9 digits).

After the operation is completed, the screen should look like this:

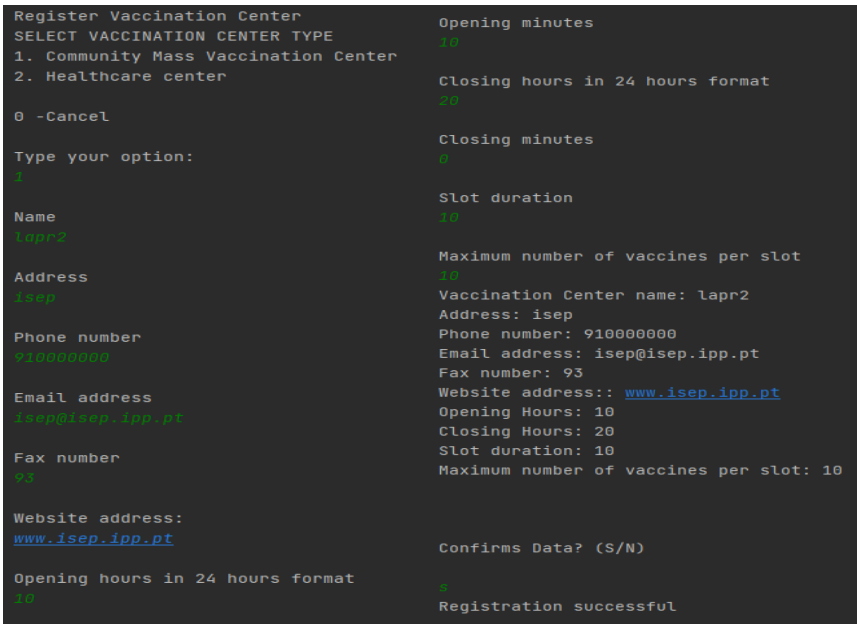


Figure 1 - Registering a new vaccination center

2.1.2. Register Employee

To register an employee, the user should:

1. Insert the name, address, phone number and citizen card number in this order (the entries cannot be null or empty, the citizen card number must have exactly 8 digits and the phone number must have 9 characters).
2. The input information will be shown and later ask for the confirmation.

After the operation's success, the screen should look like this:

```
Register Employee
SELECT ROLE:
1. RECEPTIONIST
2. CENTER COORDINATOR
3. NURSE

0 -Cancel

Type your option:
1

Name
lapr2

Address
isep

Phone number
910000000

Email address
isep@isep.ipp.pt

Citizen card number
10000000

Employee:
Employee: lapr2 - isep - 910000000 - isep@isep.ipp.pt - 10000000


Confirms Data?

s
Email address:isep@isep.ipp.pt Password:B6ek0WC
Registration successful
```

Figure 2- Registering a new employee

2.1.3. List of Employees with a given role

To get the list of employees with a given role, the user should:

1. Select the type of role, he/she wants to list, according to the given list.

After the operation's success, the screen should look like this:

```
Employee by Role
SELECT ROLE:
1. RECEPTIONIST
2. CENTER COORDINATOR
3. NURSE

0 -Cancel

Type your option:
1
List
1. Employee: lapr2 - isep - 910000000 - isep@isep.ipp.pt - 10000000

0 -Cancel
```

Figure 3- Listing employees by role

2.1.4. Specify new Vaccine Type

To start specifying a new vaccine type, the user should:

1. Insert the type of vaccine (it can be one of six types: live-attenuated vaccines, inactivated vaccines, subunit vaccines, toxoid vaccines, viral vector vaccines and messenger RNA (mRNA) vaccines).
2. Insert the type's code (the length should be between 4 and 8 characters and it cannot be null or empty)
3. Insert the designation (the length cannot exceed the 40 characters and it cannot be null or empty)

After the operation's success, the screen should look like this:

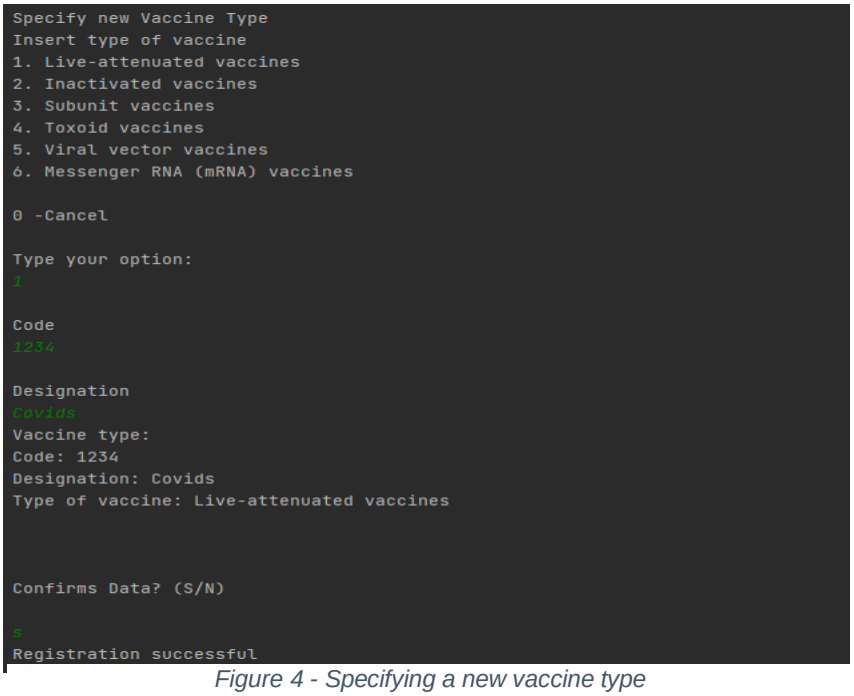


Figure 4 - Specifying a new vaccine type

2.1.5. Specify new Vaccine

To start specifying a new vaccine, the user should:

1. Choose the vaccine type from the given list.
2. Insert the Id and the name in that order (they cannot be null or empty)
3. Insert the lower and upper age limits (the upper age limit should be higher than the lower age limit)
4. If needed, insert another age group for the administration process.
5. Insert the number of doses and dosage in that order (they cannot be null or empty)
6. Specify if there are differences in the time interval in between doses for the current vaccine administration process.
   6.1 If yes, insert the number of days needed before taking the next dose (the vaccine can be taken up to 3 times)
7. Specify if there are more administration processes for the vaccine.
8. Confirm the input information shown by the application.

After the operation's success, the screen should look like this:

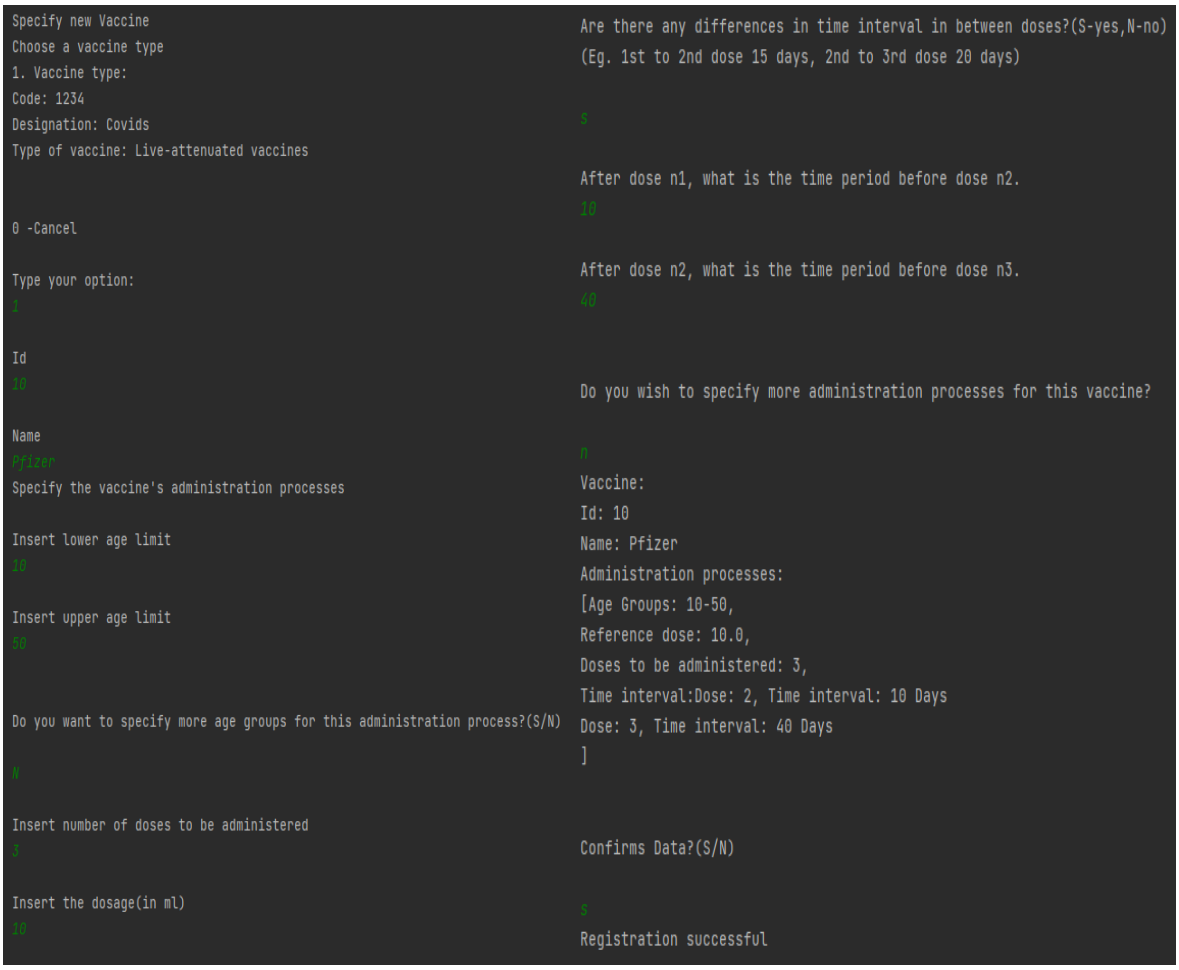


Figure 5- Specifying a new vaccine

2.1.6. Load SNS users from CSV file

To load SNS users from a CSV file, the user should:

1. Insert a valid path to the folder with the files (it should be the absolute path).
2. Select the file form the given list.
3. Confirm the application's request to import the file's data.

After confirming the data, a list of SNS users that are added or already exist in the system will appear. In the end a list of all the system users will appear and the screen should look like this:

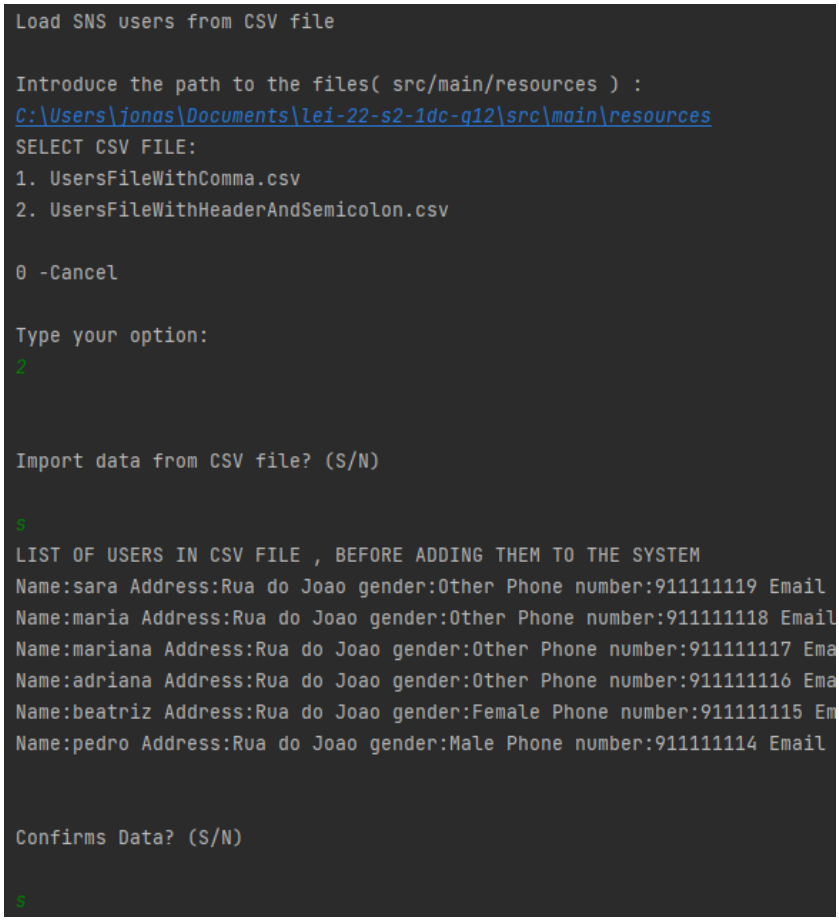


Figure 6- Loading SNS users from a CSV file

2.1.7. Export SMS notifications

Whenever a SMS notification is requested by a user, the administrator should:

1. Select the option 7 to export the notification text file with the scheduled information.

After the operation is completed, the screen should look like this:

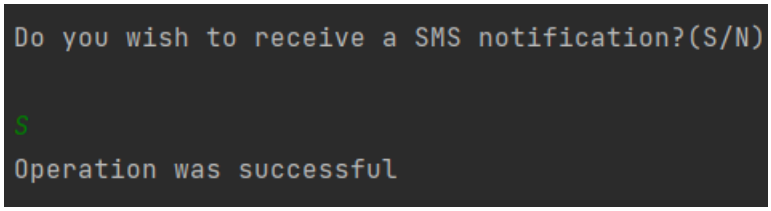


Figure 7 - Excerpt of an operation requiring the SMS notification

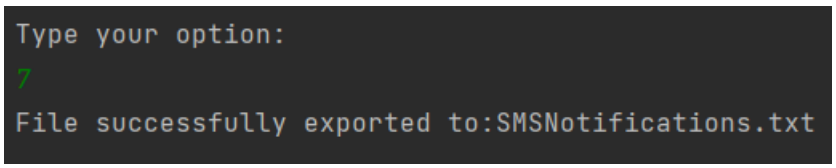


Figure 8 - Export of the SMS notification

```
TO: 919876542 Message: The user
Gilberto has a vaccination scheduled
for  Wed Jun 08 19:00:00 WEST 2022
at the vaccination center  s joao
for a vaccine of the type  flu-A.
```

Figure 9 - The SMS Notification

2.1.8. Serialization

When accessing this menu, the administrator should specify if he/she wants to serialize the system data or deserialize a file with system data.

After the operation's success, the screen should look like this:

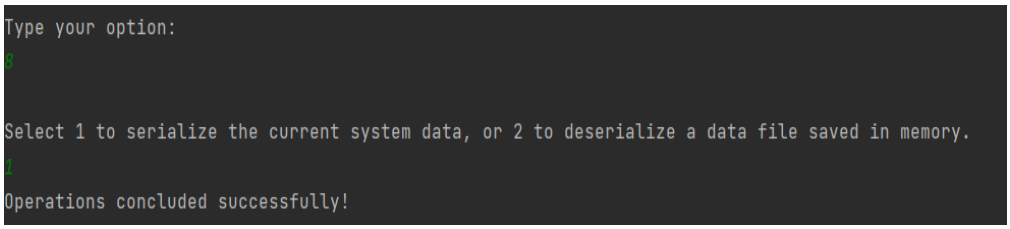


Figure 10- Serialization of the data

2.2. Center coordinator Menu

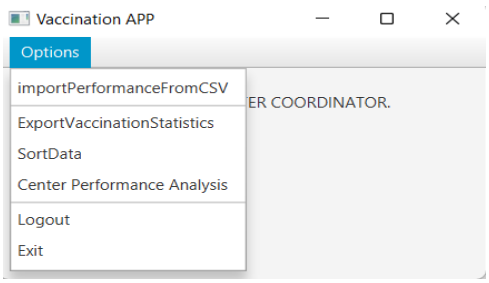


Figure 11- The Center Coordinator Menu

2.2.1. Import Performance Data from a CSV file

When importing performance data from a CSV file, the user should select the file from the file explorer

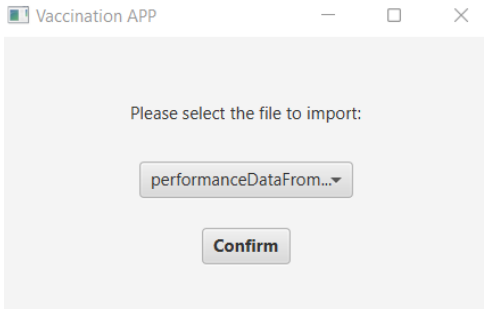


Figure 12- Selection of the CSV file

If the operation is successful, the following message will appear:

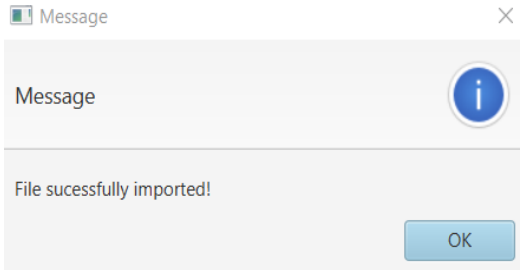


Figure 13- Operation success

2.2.2. Check and export Vaccination Statistics

Note: Before doing this option, the SNS users need to already be registered in the system, so the data from the legacy system must be imported first, if any.

When exporting vaccination statistics, the user should:

1- Specify the date interval to analyze.

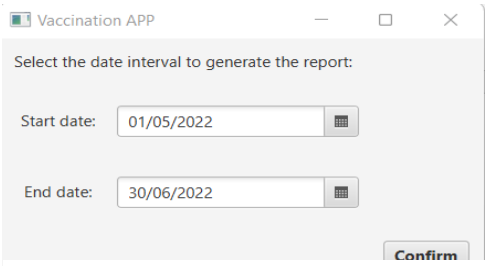


Figure 14- Selection of the date interval

2- Confirm the data shown by the application.

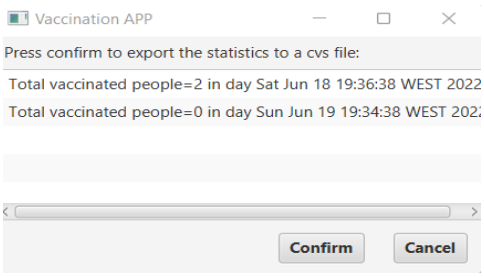


Figure 15- Vaccination statistics

3- Select the file name of the exported statistics (will automatically be converted to CSV).

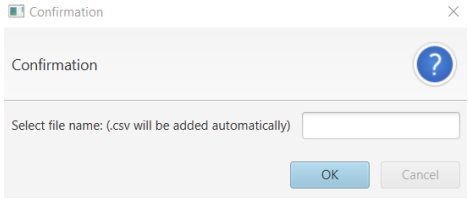


Figure 16- Naming the file to be exported

4- If the operation is successful, the following message will appear:

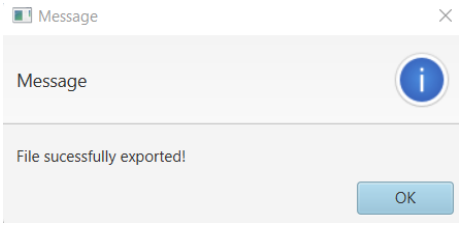


Figure 17- Operation success

2.2.3. Analyze the performance of a chosen center

Note: Before doing this option, the SNS users need to already be registered in the system, so the data from the legacy system must be imported first, if any.

When analyzing the performance of a chosen center, the user should:

1- Select the date and time interval.

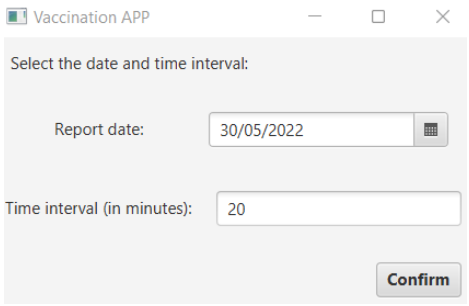


Figure 18- Selecting the date and the time interval to analyze

2- Confirm the data shown by the application.

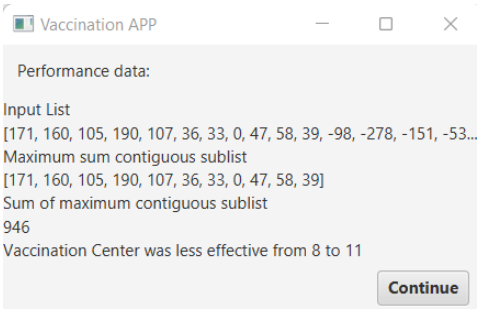


Figure 19- Performance data analyzed by the application

3- Specify if he/she wants to see the complexity analysis for predetermined time intervals.

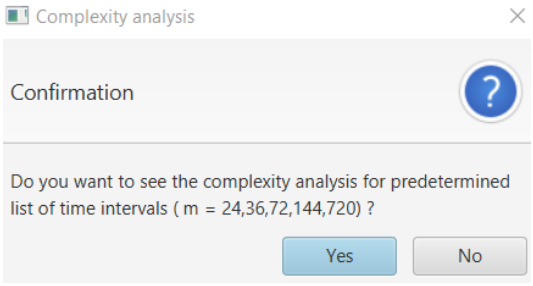


Figure 20- Confirmation to see the complexity analysis

3.1- If yes, the application will show the complexity for each predetermined time interval

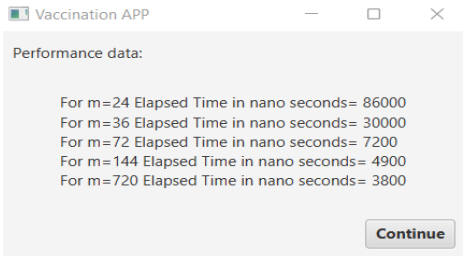


Figure 21- Time complexity for intervals of 24, 36, 72, 144 and 720

2.2.4. Sort data from a legacy system

Note: Before doing this option, the SNS users need to already be registered in the system, so the data from the legacy system must be imported first, if any.

To sort data from a legacy system, the user should:

1- Select the data to sort (arrival time or leaving time) and the sorting type (bubble sort or quick sort).

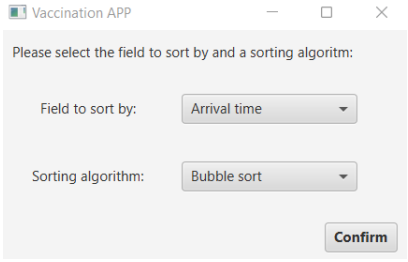


Figure 22- Selecting the preferred data to sort and its sorting method

2- After showing the sorted data, the user has the choice to do a different sort or to return to the center coordinator menu.

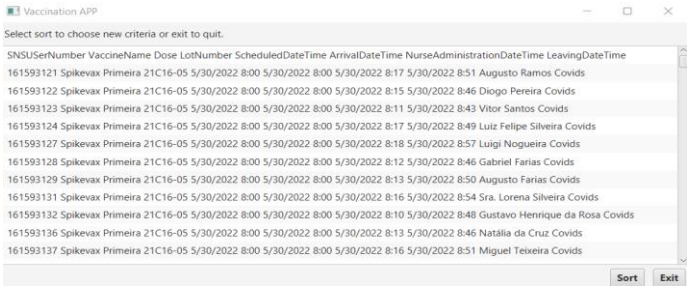


Figure 23- Sorted data by arrival time

2.3. Receptionist Menu

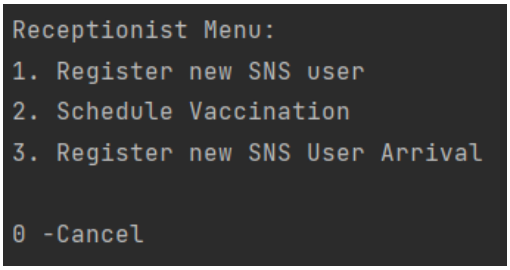


Figure 24- Receptionist menu

2.3.1. Register a new SNS User

To register a new SNS user, the user should:

1. Insert the name, address, gender, phone number, email, birth date, SNS user number and citizen card number in that order (the phone number length must be 9 characters and the SNS user and citizen card numbers' length must be 8 characters).
2. Confirm the input information shown by the application (there cannot be an instance of two registered SNS users).

When the operation ends, a new generated password will be associated with the registered SNS user's email. After the operation's success, the screen should look like this:

```
Register new SNS user
Insert user information:

Insert name:
manuel

Insert address:
rua penalves
Insert gender or select other to skip
1. Male
2. Female
3. Other

0 -Cancel

Type your option:
1

Insert phone number:
918765432

Insert email:
manuel@isep.ipp.pt

Insert birth date(Format dd-MM-yyyy):. Format dd-MM-yyyy
11-11-2000

Insert SNS User Number
15937486
Insert Citizen Card Number:
87654321
SNS User{Name='manuel', Address='rua penalves', gender='Male', Phone number='918765432', Email address='manuel@isep.ipp.pt', birth date=Sat Nov 11 00:00:00 WET 2000


Do you confirm that you want to create this user?(S/N)

S
Email address:manuel@isep.ipp.pt Password:iiQ04OM
Operations concluded successfully!
```

Figure 25 - Registering the new SNS user

2.3.2. Schedule Vaccination

To schedule a vaccination, the user should:

1. Insert the SNS user number (it must only contain 8 characters).
2. Insert the schedule's date.
3. Select the time slot from the given list.

After the operation's success, the screen should look like this:

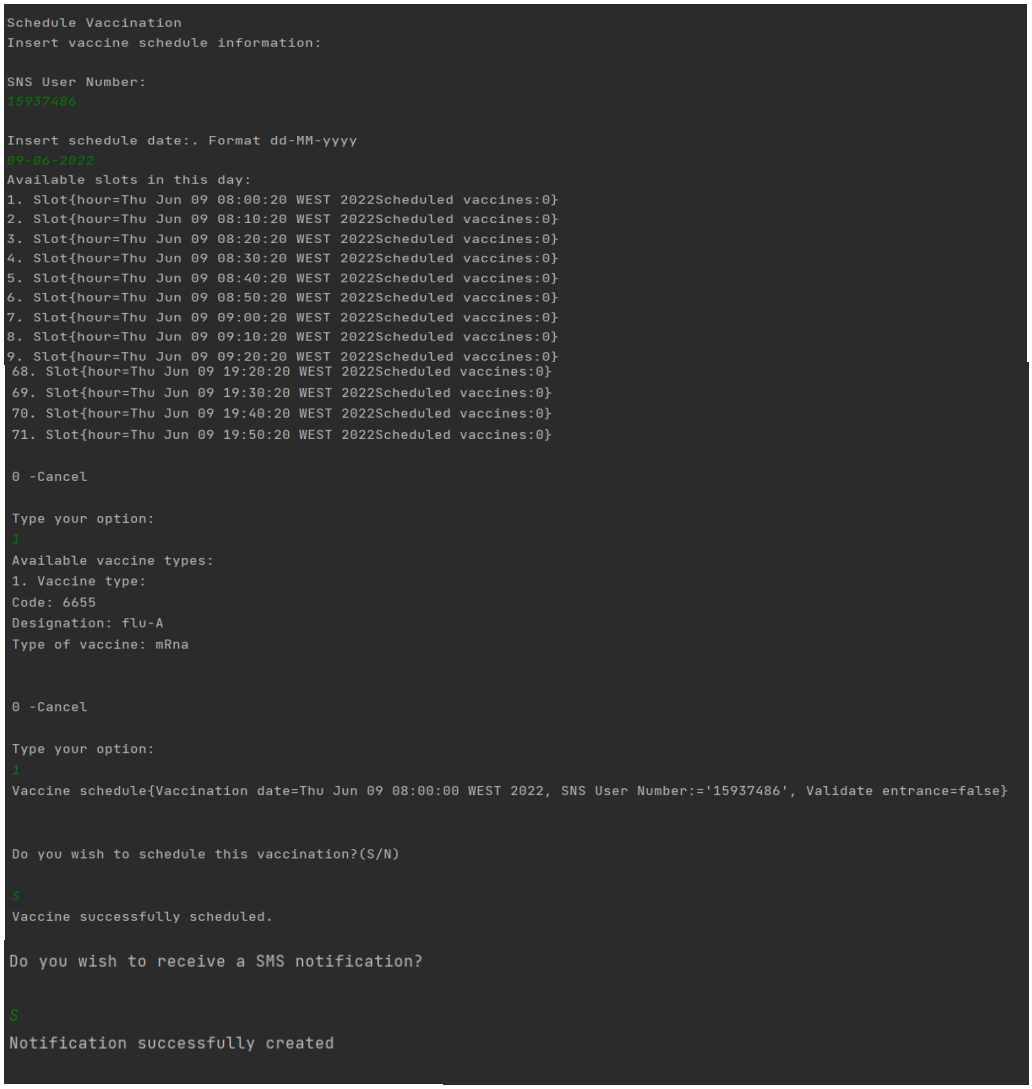


Figure 26- Scheduling the vaccination as the receptionist (some slots were omitted due to the list's size)

2.3.3. Register a new SNS User Arrival

To register a new SNS user arrival, the user should:

1. Insert the SNS user number of the user that arrived (the number must contain 8 characters)

The application will find the schedule's time slot automatically and will warn if there is a schedule for the current day.

After finishing this operation, the screen should look something like this:

```
Register new SNS User Arrival

Insert SNS User Number
15937486
SCHEDULE
Vaccine schedule{Vaccination date=Thu Jun 09 12:00:00 WEST 2022, SNS User Number:='15937486', Validate entrance=false}


A schedule for this sns user exists and was validated, send him/her to the waiting room?(S/N)

S
Registration successful
```

Figure 27 - Registering the SNS user arrival

2.4. Nurse Menu

2.4.1. Consult the users in the waiting room

To consult the users in the waiting room, the user should:

1. Confirm the data given by the list

After this operation's success, the screen should look like this:

```
List SNSUser waiting room
Waiting room SNS User order
1. SNS User{Name='jonas', Address='Rua do Joao', gender='Male', Phone number='916597411', Email address='snsuser10@lei.sem2.pt', birth date=Tue Feb 01 12:29:05 WET 1994, SNS User Number:='12345611', Citizen card number='12345611'}

0 -Cancel


Confirms Data?(S/N)

S
Operation was successful
```

Figure 28 - Consulting the users in the waiting room

2.4.2. Record an adverse reaction

To record an adverse reaction, you should already be logged in as a Nurse and the menu below will open when you click on options:

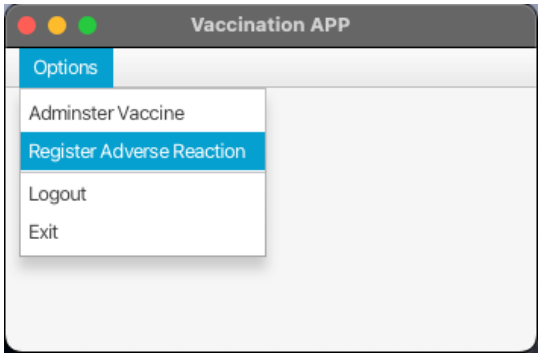


Figure 29- Nurse menu

1- After clicking on the “Register Adverse Reaction”, the program will ask you to insert the SNS User Number.

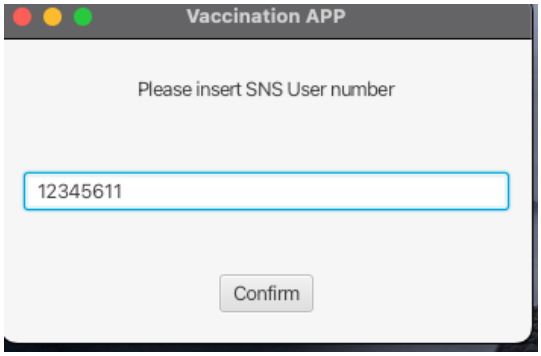


Figure 30- Inserting the SNS number

2- After inserting the SNS User number you must click on the button “Confirm”. The menu bellow will appear and ask to select a Vaccine Administration.

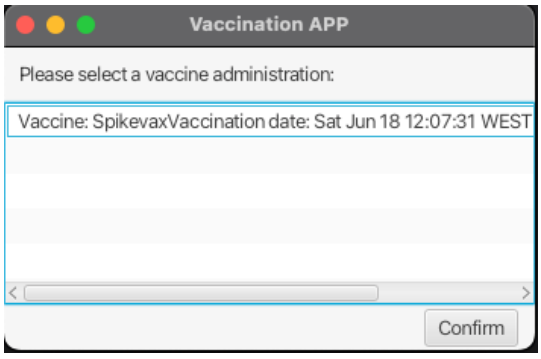


Figure 31- Selecting the vaccine to administer

3- After selecting and confirming the vaccine administration. In the Menu bellow you should insert a description of the adverse reaction and confirm,

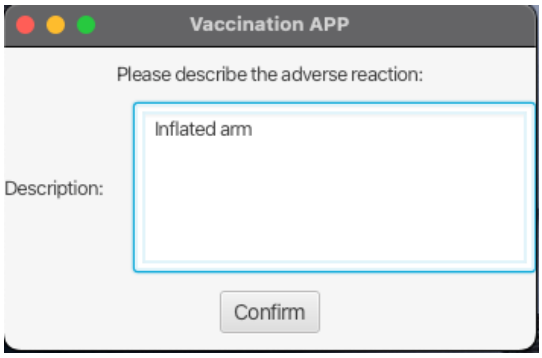


Figure 32- Insert the adverse reaction

4- After confirming, the window below will pop-up and inform you that the operation was successful.

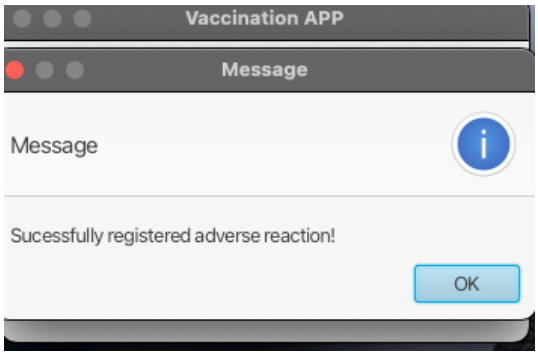


Figure 33- Operation success

2.4.3. Record the administration of a vaccine

1- To record the administration of a vaccine, you should already be logged in as a Nurse and the Menu bellow will open when you click options,

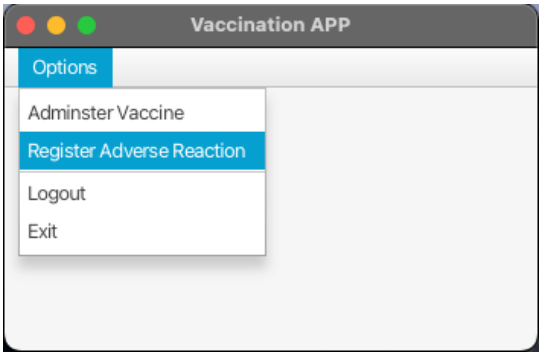


Figure 34- Nurse menu

2- After clicking “Administer Vaccine”, the menu below will open showing the users in the Waiting Room,

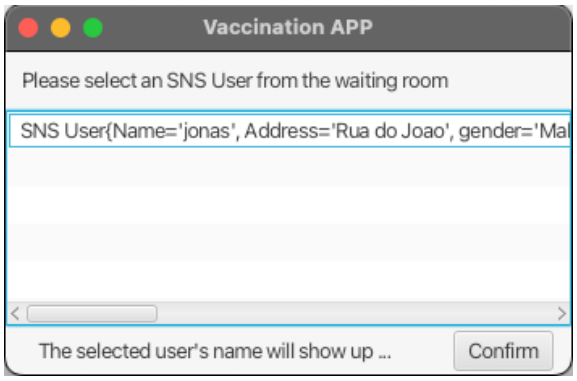


Figure 35- Selecting the SNS user

3- After selecting and confirming the SNS User, the menu below will appear and will show the dosage and the SNS User past adverse reactions. The Nurse will have to insert the lot number and confirm,

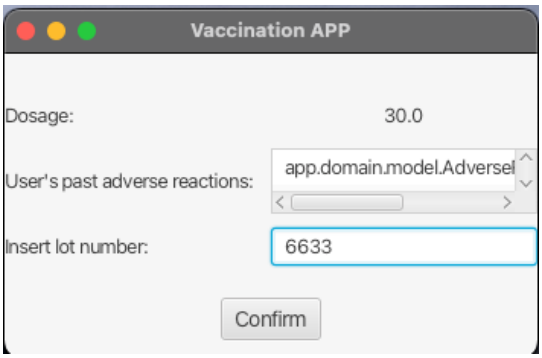


Figure 36- Confirming the information about the vaccine administration

4- After confirming the lot number, there will appear the menu below showing the inserted/selected data and the Nurse should confirm or cancel,

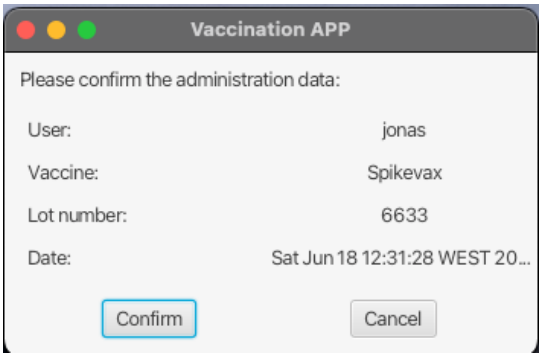


Figure 37- Vaccine administration data

If the “Confirm” button is clicked, the window below will pop up,

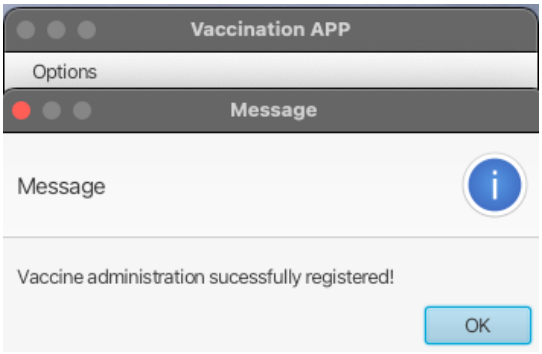


Figure 38- Operation success

2.5. SNS User Menu

2.5.1. Schedule a Vaccination

To schedule a vaccination, the user should:

1. Choose a vaccination center from a given list.
2. Choose the vaccine type from the given list.
3. Insert the vaccination schedule’s date (it must be in the following format: *dd-MM-yyyy*).
4. Select the preferred time slot from the given list.
5. Specify if he/she wants to receive a SMS notification.

After the operation’s success, the screen should look like this:

```
Type your option:
1
Select a vaccination center
1. Vaccination Center name: s joao
Address: porto
Phone number: 916597487
Email address: vaccinationcenterLAPR2@gmail.com
Fax number: 2525
Website address:: www.sns.pt
Opening Hours: 8
Closing Hours: 20
Slot duration: 10
Maximum number of vaccines per slot: 10


0 -Cancel

Type your option:
1
Choose a vaccine type
1. Vaccine type:
Code: 6655
Designation: flu-A
Type of vaccine: mRna


0 -Cancel

Type your option:
1
```

```
Insert schedule date:. Format dd-MM-yyyy
08-06-2022
Available slots in this day:
1. Slot{hour=Wed Jun 08 18:40:00 WEST 2022Scheduled vaccines:0}
2. Slot{hour=Wed Jun 08 18:50:00 WEST 2022Scheduled vaccines:0}
3. Slot{hour=Wed Jun 08 19:00:00 WEST 2022Scheduled vaccines:0}
4. Slot{hour=Wed Jun 08 19:10:00 WEST 2022Scheduled vaccines:0}
5. Slot{hour=Wed Jun 08 19:20:00 WEST 2022Scheduled vaccines:0}
6. Slot{hour=Wed Jun 08 19:30:00 WEST 2022Scheduled vaccines:0}
7. Slot{hour=Wed Jun 08 19:40:00 WEST 2022Scheduled vaccines:0}
8. Slot{hour=Wed Jun 08 19:50:00 WEST 2022Scheduled vaccines:0}

0 -Cancel

Type your option:
1
Vaccine schedule{Vaccination date=Wed Jun 08 19:00:00 WEST 2022, SNS User Number:='36582157', Validate entrance=false}


Do you wish to schedule this vaccination?(S/N)

S
Operation was successful


Do you wish to receive a SMS notification?(S/N)

S
Operation was successful
```

Figure 39- Scheduling the vaccination as the SNS user

Troubleshoot

ISSUE #1- The application does not login

Have you selected the option 1. before writing your credentials? If not, select the option and then, write the credentials.

ISSUE #2- The application cannot use the center coordinator menu correctly

If you are not able to analyze or sort the center performance, you should check if the data has already been imported to the system.

Contacts

If your problem has not been solved, contact us through here:

- 1181478@isep.ipp.pt
- 1191038@isep.ipp.pt
- 1211008@isep.ipp.pt
- 1211154@isep.ipp.pt
- 1211690@isep.ipp.pt

FAQS

Q# Do I need to be registered in a specific vaccination center to analyze its performance?

A# Yes, if you are a Center Coordinator and you are not registered, please ask an administrator to add you to your working Vaccination Center.

Q# As a SNS User, can I schedule more than one Vaccine?

A# Yes, you are able to schedule one Vaccine per Vaccine schedule as the same SNS User.

Q# As a SNS User, can I schedule a Vaccine for a family member?

A# No, you can only schedule Vaccines for the logged in SNS User. In case, you are the one scheduling your family member Vaccine, you will have to go to the Vaccination Center in which your family member will be vaccinated.

Glossary

Term	Translation to Portuguese	Meaning
Administrator	Administrador	Professional that manages the application.
Bubble sort	Bubble sort	Simple sorting algorithm.
Center Coordinator	Coordenador do Centro	Organizer that manages the vaccination center.
Covid-19	Covid-19	Infectious disease caused by the SARS-CoV-2 virus.
CSV	CSV	File with a specified format for storing data in a table-structured format.
Dose	Dose	Measured amount of the vaccine
Nurse	Enfermeira	Health professional, qualified to care for the sick.
Quick sort	Quick sort	Sorting algorithm that is faster on average than bubble sort.
Serialization	Serialização	Act of saving data on a file so it can be used later.
SMS	SMS	Message service for mobile phones
SNS	SNS	State organization that ensures every citizen has the right to health.
Time complexity analysis	Análise da complexidade do tempo	Analysis that shows how much time the application takes to do an operation.
User	Utilizador	Person or organization that uses a certain type of service.
Vaccination	Vacinação	Act of vaccinating.
Vaccine	Vacina	Substance that provides immunity against one or more diseases.
Vaccination Center	Centro de Vacinação	Location where the vaccine is administrated.

Annex A - MATCP

Simple linear regression or SLR

In statistics, simple linear regression is a linear regression model with a single explanatory variable. That is, it concerns two-dimensional sample points with one independent variable and one dependent variable and finds a linear function (a non-vertical straight line) that predicts, as accurately as possible, the dependent variable values as a function of the independent variable.

Formulas used in SLR

Coefficients

Coefficient b

$$S_{xx} = \sum_{i=1}^{n}(x_i - \bar{x})^2 = \sum_{i=1}^{n} x_i^2 - n\bar{x}^2$$

Formula 1_Matcp_teórica7_slide10

$$S_{xy} = \sum_{i=1}^{n}(x_i - \bar{x})(y_i - \bar{y}) = \sum_{i=1}^{n} x_i y_i - n\bar{x}\bar{y}$$

Formula 2_Matcp_teórica7_slide10

$$S_{yy} = \sum_{i=1}^{n}(y_i - \bar{y})^2 = \sum_{i=1}^{n} y_i^2 - n\bar{y}^2$$

Formula 3_Matcp_teórica7_slide11

$$\hat{b} = \frac{S_{xy}}{S_{xx}}$$

Formula 4_Matcp_teórica7_slide10

Coefficient a

$$\hat{a} = \bar{y} - \hat{b}\bar{x}$$

Formula 5_Matcp_teórica7_slide11

Multiple R and R square

$$R = \frac{S_{xy}}{\sqrt{S_{xx}}\sqrt{S_{yy}}}$$

Formula 6_Matcp_teórica7_slide12

$$R^2 = \frac{S_{xy}^2}{S_{xx}S_{yy}}$$

Formula 7_Matcp_teórica7_slide13

Adjusted R square

$$R^2_{ajust.} = 1 - \left(\frac{n-1}{n-(k+1)}\right)(1-R^2)$$

Formula 8_Matcp_teórica8_slide28

Standard Error (square root of the next formula)

$$s^2 = \frac{1}{n-2}\sum_{i=1}^{n}(y_i - \hat{y}_i)^2$$

Formula 9_Matcp_teórica7_slide20

Confidence Intervals

Parameter a and Parameter b

$$\left]\hat{a}-t_c s\sqrt{\frac{1}{n}+\frac{\bar{x}^2}{S_{xx}}},\hat{a}+t_c s\sqrt{\frac{1}{n}+\frac{\bar{x}^2}{S_{xx}}}\right[$$

Formula 10_Matcp_teórica7_slide21

$$\left]\hat{b}-t_c s\sqrt{\frac{1}{S_{xx}}},\hat{b}-t_c s\sqrt{\frac{1}{S_{xx}}}\right[$$

Formula 11_Matcp_teórica7_slide22

Hypothesis tests

Parameter a and Parameter b

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

Formula 12_Matcp_teórica7_slide23

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

Formula 13_Matcp_teórica7_slide24

Anova

Sum of Squares (SS)

$$SR=\sum_{i=1}^{n}\left(\hat{Y}_i-\bar{Y}\right)^2$$

Formula 14_Matcp_teórica7_slide31

$$SE=\sum_{i=1}^{n}\left(Y_i-\hat{Y}_i\right)^2$$

Formula 15_Matcp_teórica7_slide31

$$ST=\sum_{i=1}^{n}\left(Y_i-\bar{Y}\right)^2$$

Formula 16_Matcp_teórica7_slide30

Mean Square (MS)

$$MSR=\frac{SR}{1}$$

Formula 17_Matcp_teórica7_slide34

$$MSE=\frac{SE}{n-2}$$

Formula 18_Matcp_teórica7_slide34

Test statistic

$$F=\frac{MSR}{MSE}$$

Equation 19_Matcp_teórica7_slide35

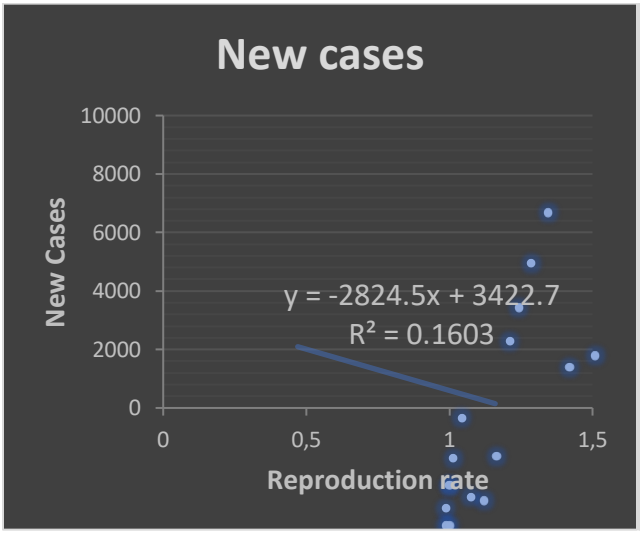
Reproduction rate – New cases

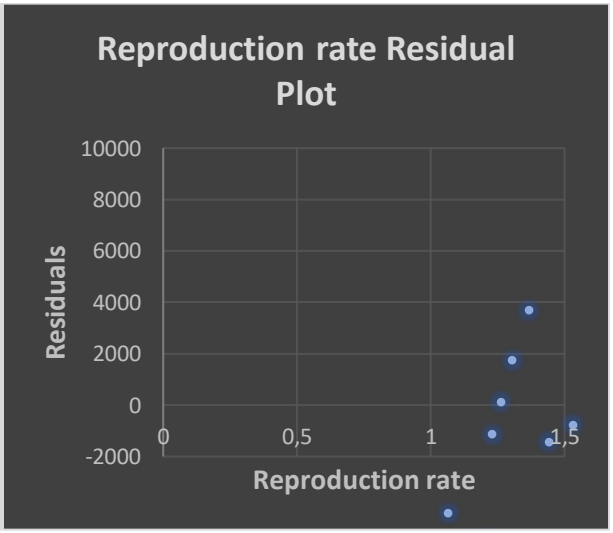
Regression Statistics	
Multiple R	-0.4004
R Square	0.1603
Adjusted R Square	0.1532
Standard Error	1426.0199
Observations	120.0000

ANOVA

	df	*SS*	*MS*	*F*
Regression	1.0000	45823995.3087	45823995.3087	22.5342
Residual	118.0000	239956860.6163	2033532.7171	
Total	119.0000	285780855.9250		

	Coefficients	*Standard Error*	*t Stat*	*Lower 95%*	*Upper 95%*
Intercept	3422.6644	512.1195	6.6833	2408.5284	4436.8005
Reproduction rate	-2824.5343	595.0123	-4.7470	-4002.8207	-1646.2479





new cases = 3422.6644-2824.5343 (reproduction rate)

The reproduction rate coefficient in the regression equation is -2824.5343. This coefficient represents the mean decrease of new cases for every additional increase in reproduction rate. If the reproduction rate increases by 1, the average new cases decrease by -2824.5343.

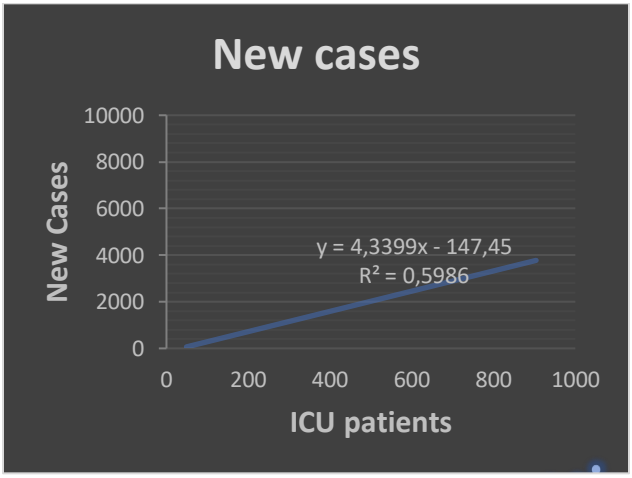
ICU patients – New cases

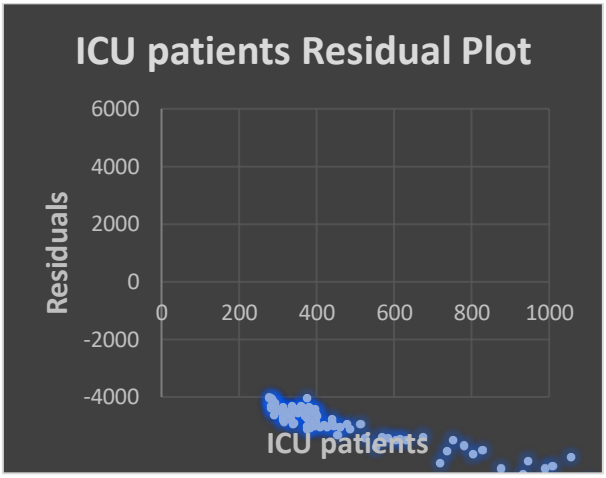
Regression Statistics	
Multiple R	0.7737
R Square	0.5986
Adjusted R Square	0.5952
Standard Error	986.0298
Observations	120.0000

ANOVA

	df	*SS*	*MS*	*F*
Regression	1.0000	171054792.2903	171054792.2903	175.9362
Residual	118.0000	114726063.6347	972254.7766	
Total	119.0000	285780855.9250		

	Coefficients	*Standard Error*	*t Stat*	*Lower 95%*	*Upper 95%*
Intercept	-147.4516	128.6356	-1.1463	-402.1852	107.2820
ICU patients	4.3399	0.3272	13.2641	3.6920	4.9878





new cases = -147.4510 + 4.3399 (icu_patients)

The ICU patients coefficient in the regression equation is 4.3399. This coefficient represents the mean increase of new cases for every additional increase in ICU patients. If the ICU patients increase by 1, the average new cases increase by 4.3399.

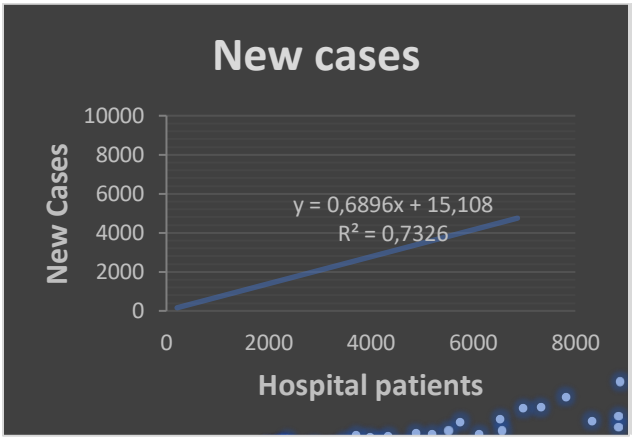
Hospital patients – New Cases

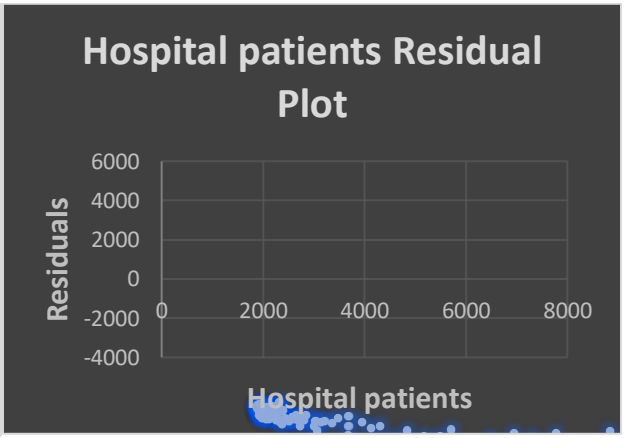
Regression Statistics	
Multiple R	0.8559
R Square	0.7326
Adjusted R Square	0.7304
Standard Error	804.6905
Observations	120.0000

ANOVA

	df	*SS*	*MS*	*F*
Regression	1.0000	209372686.8504	209372686.8504	323.3421
Residual	118.0000	76408169.0746	647526.8566	
Total	119.0000	285780855.9250		

	Coefficients	*Standard Error*	*t Stat*	*Lower 95%*	*Upper 95%*
Intercept	15.1080	94.0597	0.1606	-171.1560	201.3719
Hospital patients	0.6896	0.0383	17.9817	0.6136	0.7655





new cases = 15.108 + 0.6896 (hosp_patients)

The Hospital patients coefficient in the regression equation is 0.6896. This coefficient represents the mean increase of new cases for every additional increase in Hospital patients. If the Hospital patients increase by 1, the average new cases increase by 0.6896.

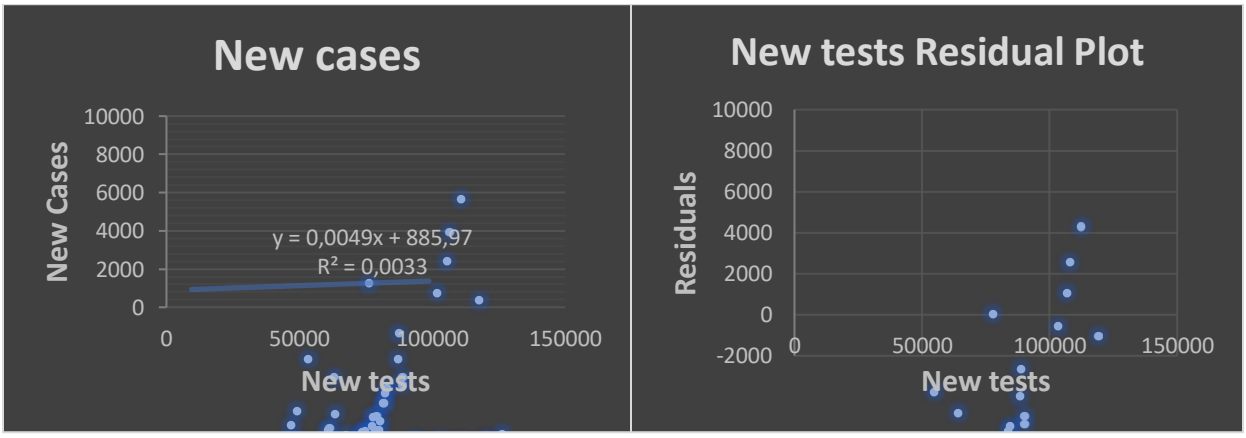
New Tests – New Cases

Regression Statistics	
Multiple R	0,0576
R Square	0,0033
Adjusted R Square	-0,0051
Standard Error	1553,6553
Observations	120,0000

ANOVA

	df	*SS*	*MS*	*F*
Regression	1,0000	947182,6023	947182,6023	0,3924
Residual	118,0000	284833673,3227	2413844,6892	
Total	119,0000	285780855,9250		

	Coefficients	*Standard Error*	*t Stat*	*Lower 95%*	*Upper 95%*
Intercept	885,9702	328,3484	2,6983	235,7510	1536,1893
New tests	0,0049	0,0079	0,6264	-0,0107	0,0206



new cases = 885.9702 + 0.0049 (new tests)

The new tests coefficient in the regression equation is 0.0049. This coefficient represents the mean increase of new cases for every additional increase in new tests. If the new tests increase by 1, the average new cases increase by 0.0049.

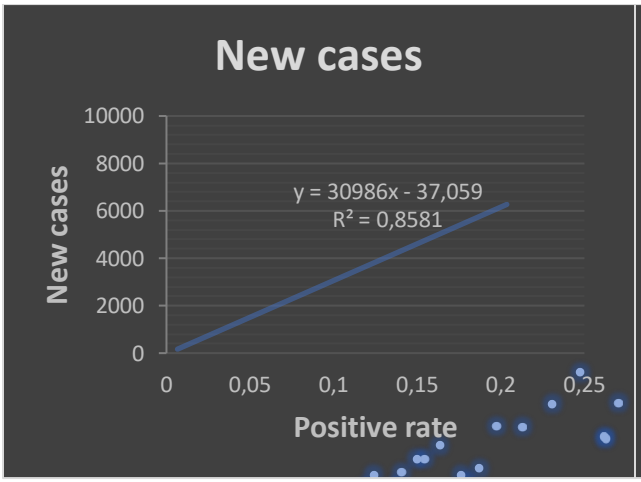
Positive Rate – New Cases

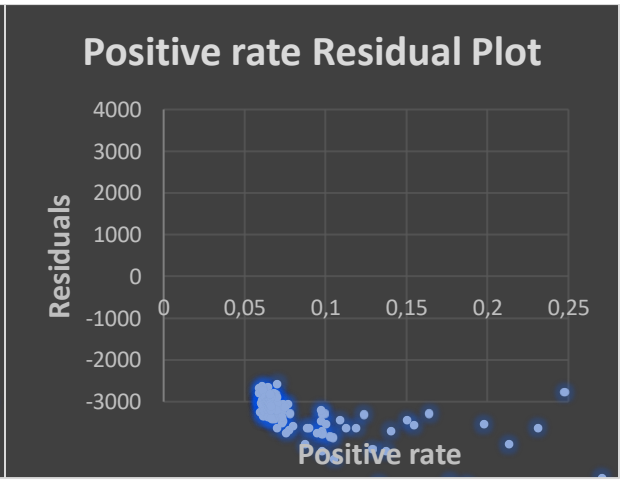
Regression Statistics	
Multiple R	0,9264
R Square	0,8581
Adjusted R Square	0,8569
Standard Error	586,1722
Observations	120,0000

ANOVA

	df	*SS*	*MS*	*F*
Regression	1,0000	245236314,7923	245236314,7923	713,7307
Residual	118,0000	40544541,1327	343597,8062	
Total	119,0000	285780855,9250		

	Coefficients	*Standard Error*	*t Stat*	*Lower 95%*	*Upper 95%*
Intercept	-37,0594	67,7129	-0,5473	-171,1495	97,0306
Positive rate	30986,2874	1159,8514	26,7157	28689,4658	33283,1089





new cases = -37.0594 + 30986.2874 (positive rate)

The positive rate coefficient in the regression equation is 30986.2874. This coefficient represents the mean increase of new cases for every additional increase in positive rate. If the positive rate increases by 1, the average new cases increase by 30986.2874.

Fully Vaccinated People – New Cases

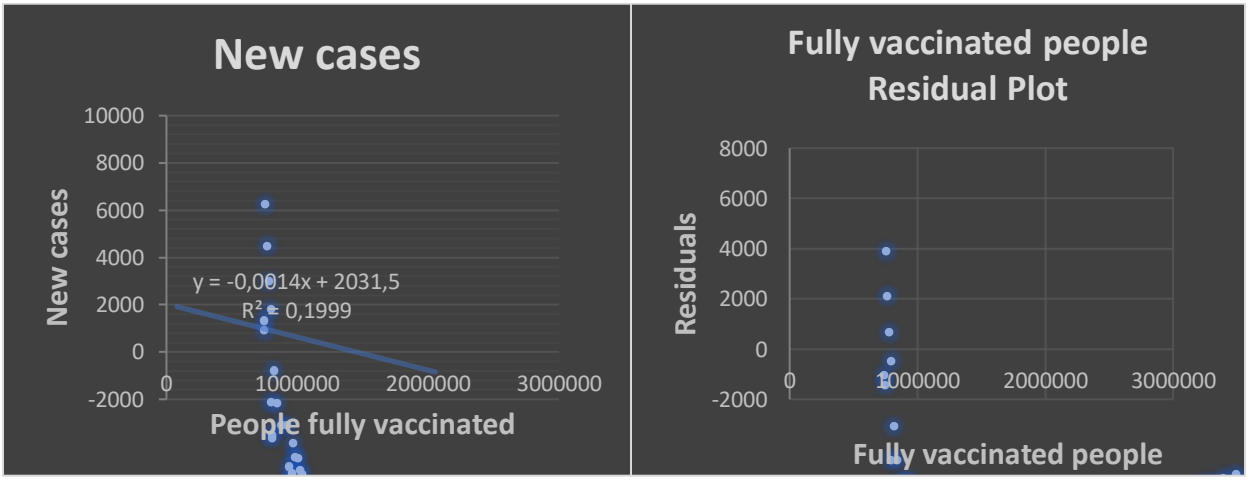
Regression Statistics	
Multiple R	-0,4471
R Square	0,1999

Adjusted R Square	0,1931
Standard Error	1392,0612
Observations	120,0000

ANOVA

	df	*SS*	*MS*	*F*
Regression	1,0000	57116397,0107	57116397,0107	29,4743
Residual	118,0000	228664458,9143	1937834,3976	
Total	119,0000	285780855,9250		

	Coefficients	*Standard Error*	*t Stat*	*Lower 95%*	*Upper 95%*
Intercept	2031,5054	217,7578	9,3292	1600,2856	2462,7252
Fully vaccinated people	-0,0014	0,0003	-5,4290	-0,0019	-0,0009



new cases = 2031.5054 -0.0014 (fully vaccinated people)

The fully vaccinated people coefficient in the regression equation is -0.0014. This coefficient represents the mean decrease of new cases for every additional increase in fully vaccinated people. If the fully vaccinated people increase by 1, the average new cases decrease by -0.0014.

Reproduction Rate – New Deaths

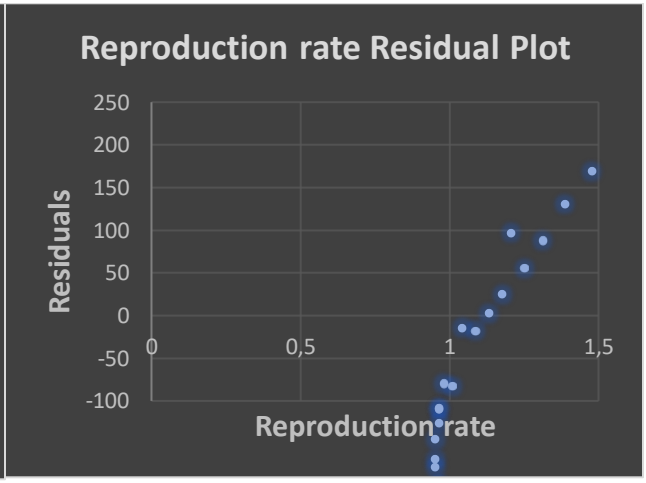
Regression Statistics	
Multiple R	-0,5786
R Square	0,3347
Adjusted R Square	0,3291
Standard Error	54,3749

Observations	120,0000

ANOVA

	df	*SS*	*MS*	*F*
Regression	1,0000	175551,9475	175551,9475	59,3756
Residual	118,0000	348882,6441	2956,6326	
Total	119,0000	524434,5917		

	Coefficients	*Standard Error*	*t Stat*	*Lower 95%*	*Upper 95%*
Intercept	183,3855	19,5274	9,3912	144,7159	222,0550
Reproduction rate	-174,8249	22,6881	-7,7056	-219,7536	-129,8962



new deaths = 183.3855 -174.8249 (reproduction rate)

The reproduction rate coefficient in the regression equation is -174.8249. This coefficient represents the mean decrease of new deaths for every additional increase in reproduction rate. If the reproduction rate increases by 1, the average new deaths decrease by -174.8249.

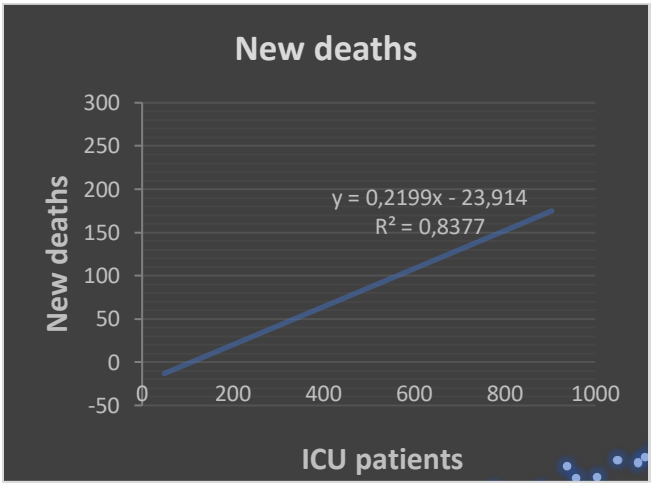
ICU Patients – New Deaths

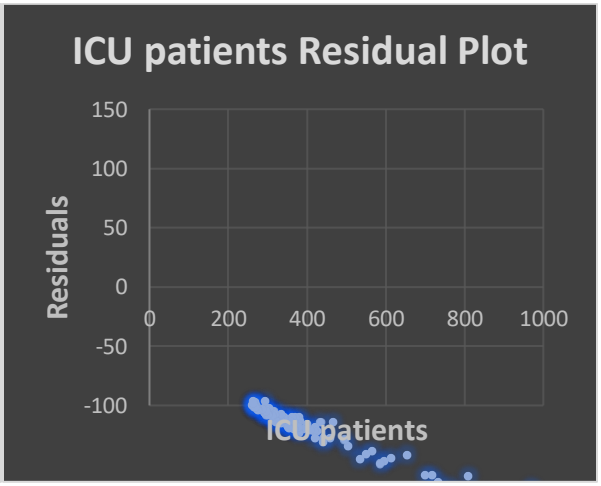
Regression Statistics	
Multiple R	0,9153
R Square	0,8377
Adjusted R Square	0,8363
Standard Error	26,8588
Observations	120,0000

ANOVA

	df	*SS*	*MS*	*F*
Regression	1,0000	439310,0949	439310,0949	608,9738
Residual	118,0000	85124,4968	721,3940	
Total	119,0000	524434,5917		

	Coefficients	*Standard Error*	*t Stat*	*Lower 95%*	*Upper 95%*
Intercept	-23,9142	3,5039	-6,8249	-30,8530	-16,9754
ICU patients	0,2199	0,0089	24,6774	0,2023	0,2376





new deaths = -23.9142 + 0.2199 (ICU patients)

The ICU patients coefficient in the regression equation is 0.2199. This coefficient represents the mean increase of new deaths for every additional increase in ICU patients. If the ICU patients increase by 1, the average new deaths increase by 0.2199.

Hospital Patients – New Deaths

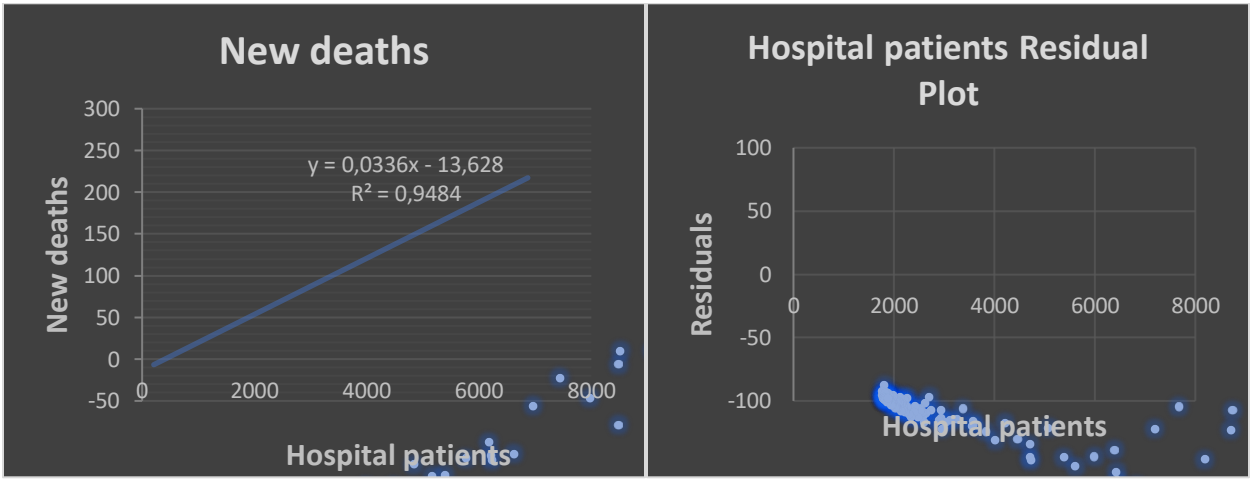
Regression Statistics	
Multiple R	0,9738
R Square	0,9484
Adjusted R Square	0,9479
Standard Error	15,1476

Observations	120,0000

ANOVA

	df	*SS*	*MS*	*F*
Regression	1,0000	497359,6499	497359,6499	2167,6294
Residual	118,0000	27074,9418	229,4487	
Total	119,0000	524434,5917		

	Coefficients	*Standard Error*	*t Stat*	*Lower 95%*	*Upper 95%*
Intercept	-13,6278	1,7706	-7,6968	-17,1340	-10,1215
Hosp patients	0,0336	0,0007	46,5578	0,0322	0,0350



new deaths = -13.6278 + 0.0336 (Hosp patients)

The Hosp patients coefficient in the regression equation is 0.0336. This coefficient represents the mean increase of new deaths for every additional increase in Hosp patients. If the Hosp patients increase by 1, the average new deaths increase by 0.0336.

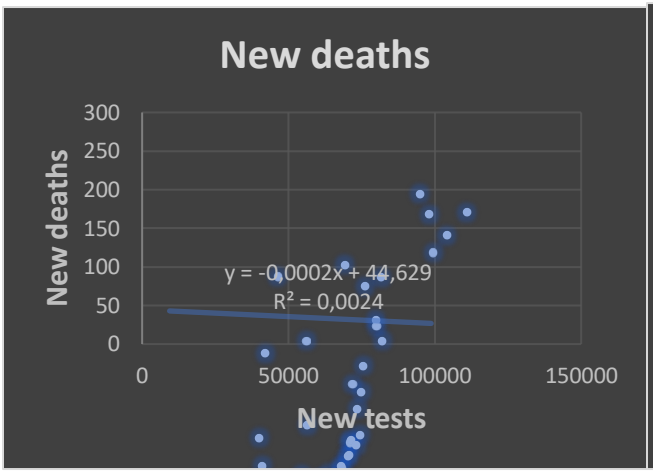
New Tests – New Deaths

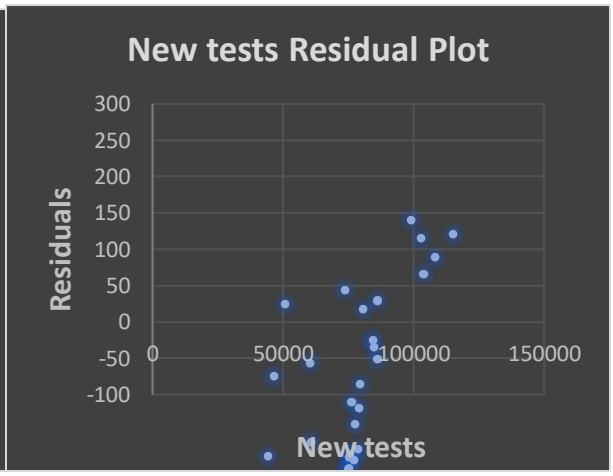
Regression Statistics	
Multiple R	-0,0490
R Square	0,0024
Adjusted R Square	-0,0060
Standard Error	66,5858
Observations	120,0000

ANOVA

	df	*SS*	*MS*	*F*
Regression	1,0000	1261,6708	1261,6708	0,2846
Residual	118,0000	523172,9209	4433,6688	
Total	119,0000	524434,5917		

	Coefficients	*Standard Error*	*t Stat*	*Lower 95%*	*Upper 95%*
Intercept	44,6287	14,0722	3,1714	16,7619	72,4955
New tests	-0,0002	0,0003	-0,5334	-0,0009	0,0005





new deaths = 44.6287 -0.0002 (new tests)

The new tests coefficient in the regression equation is -0.0002. This coefficient represents the mean decrease of new deaths for every additional increase in new tests. If the new tests increase by 1, the average new deaths decrease by -0.0002.

Positive Rate – New Deaths

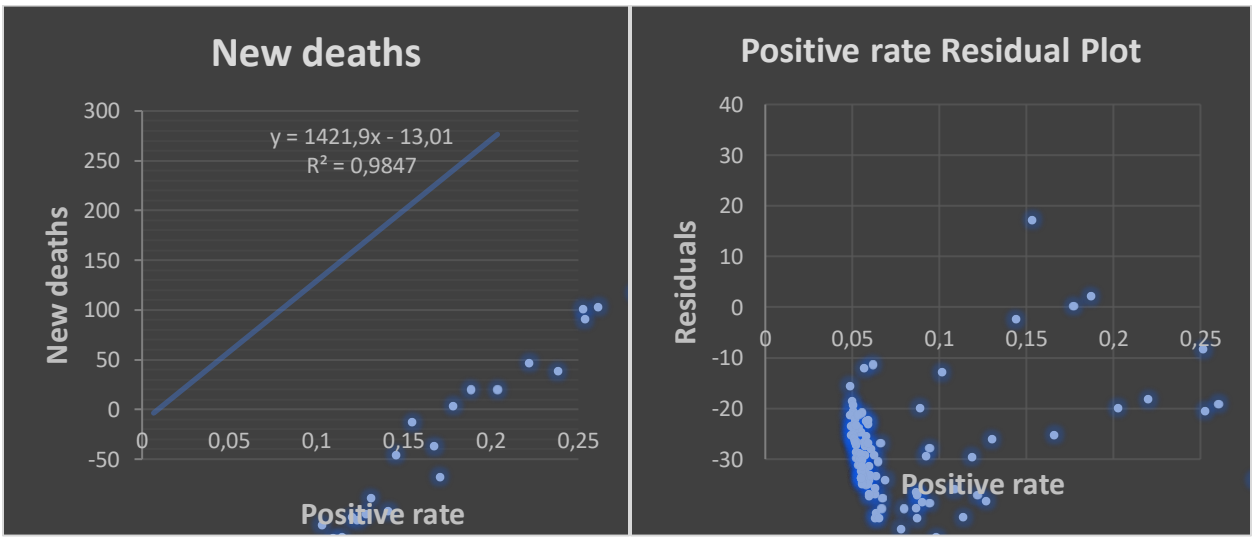
Regression Statistics	
Multiple R	0,9923
R Square	0,9847
Adjusted R Square	0,9845

Standard Error	8,2575
Observations	120,0000

ANOVA

	df	*SS*	*MS*	*F*
Regression	1,0000	516388,5104	516388,5104	7573,1082
Residual	118,0000	8046,0813	68,1871	
Total	119,0000	524434,5917		

	Coefficients	*Standard Error*	*t Stat*	*Lower 95%*	*Upper 95%*
Intercept	-13,0097	0,9539	-13,6386	-14,8987	-11,1208
Positive rate	1421,8882	16,3391	87,0236	1389,5323	1454,2440



new deaths = -13.0097 + 1421.8882 (positive rate)

The positive rate coefficient in the regression equation is 1421.8882. This coefficient represents the mean increase of new deaths for every additional increase in positive rate. If the positive rate increases by 1, the average new deaths increase by 1421.8882.

Fully Vaccinated People– New Deaths

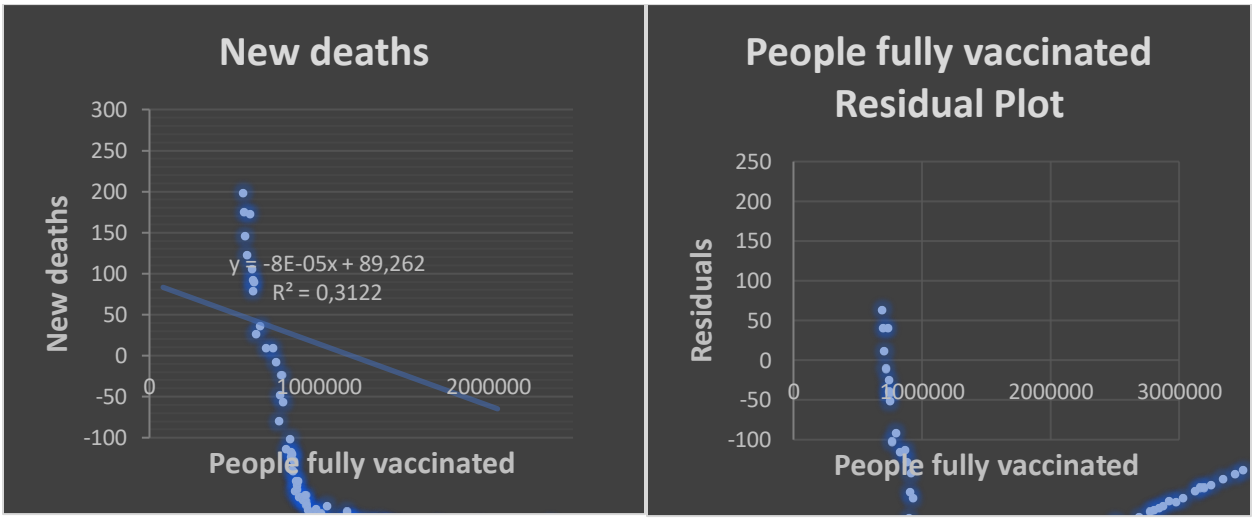
Regression Statistics	
Multiple R	-0,5588
R Square	0,3122
Adjusted R Square	0,3064

Standard Error	55,2871
Observations	120,0000

ANOVA

	df	*SS*	*MS*	*F*
Regression	1,0000	163748,3840	163748,3840	53,5710
Residual	118,0000	360686,2077	3056,6628	
Total	119,0000	524434,5917		

	Coefficients	*Standard Error*	*t Stat*	*Lower 95%*	*Upper 95%*
Intercept	89,2619	8,6485	10,3211	72,1356	106,3882
Fully vaccinated people	-0,0001	0,0000	-7,3192	-0,0001	-0,0001



new deaths = 89.2619 -0.00008 (fully vaccinated people)

The fully vaccinated people coefficient in the regression equation is -0.00008. This coefficient represents the mean decrease of new deaths for every additional increase in fully vaccinated people. If the fully vaccinated people increase by 1, the average new deaths decrease by -0.00008.

Multi linear regression or MLR

Multiple linear regression refers to a statistical technique that uses two or more independent variables to predict the outcome of a dependent variable. This technique enables analysts to determine the variation of the model and the relative contribution of each independent variable in the total variance.

Formulas used in MLR

Coefficients

$$\hat{\boldsymbol{\beta}} = (X^T X)^{-1} X^T Y$$

Formula 20_Matcp_teórica8_slide25

Anova

Sum of Squares (SS)

$$SQ_R = \hat{\boldsymbol{\beta}}^T X^T Y - n\bar{y}^2 \qquad SQ_E = Y^T Y - \hat{\boldsymbol{\beta}}^T X^T Y$$

$$SQ_T = Y^T Y - \frac{\left(\sum_{i=1}^{n} y_i\right)^2}{n} = Y^T Y - n\bar{y}^2$$

Formula 21_Matcp_teórica8_slide26 *Formula 22_Matcp_teórica8_slide26* *Formula 23_Matcp_teórica8_slide26*

Mean Square(MS)

$$MQ_R = \frac{SQ_R}{k}$$

$$MQ_E = \frac{SQ_E}{n-(k+1)}$$

Formula 24_Matcp_teórica8_slide16 *Equation 25_Matcp_teórica8_slide16*

Test statistic

$$F_0 = \frac{MQ_R}{MQ_E}$$

Equation 26_Matcp_teórica8_slide15

Adjusted R square

R square and Multiple R (square root of R square)

$$R^2_{ajust.} = 1 - \left(\frac{n-1}{n-(k+1)}\right)(1-R^2)$$

Formula 27_Matcp_teórica8_slide28

$$R^2 = \frac{SQ_R}{SQ_T}$$

Formula 28_Matcp_teórica8_slide17

Confidence Intervals

Regression Coefficients

$$\left]\hat{\beta}_j - t_{1-\alpha/2}[n-(k+1)]\sqrt{\hat{\sigma}^2 C_{jj}}\ ,\hat{\beta}_j + t_{1-\alpha/2}[n-(k+1)]\sqrt{\hat{\sigma}^2 C_{jj}}\right[$$

Formula 29_Matcp_teórica8_slide18

Expected values E(Y0)

$$\left]\hat{\mu}_{Y_0} - t_{1-\alpha/2[n-(k+1)]}\sqrt{\hat{\sigma}^2 x_0^T C x_0}\ ,\ \hat{\mu}_{Y_0} + t_{1-\alpha/2[n-(k+1)]}\sqrt{\hat{\sigma}^2 x_0^T C x_0}\right[$$

Formula 30_Matcp_teórica8_slide19

Answer prediction Y0

$$\left]\hat{y}_0 - t_{1-\alpha/2[n-(k+1)]}\sqrt{\hat{\sigma}^2\ (1 + x_0^T C x_0)}\ ,\hat{y}_0 + t_{1-\alpha/2[n-(k+1)]}\sqrt{\hat{\sigma}^2\ (1 + x_0^T C x_0)}\right[$$

Formula 31_Matcp_teórica8_slide20

Standard Error

$$\sqrt{\hat{\sigma}^2 C_{jj}}$$

Formula 32_Matcp_teórica8_slide18

Hypothesis tests

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

Formula 33_Matcp_teórica8_slide21

6 – New Cases

Regression Statistics	
Multiple R	0,9522
R Square	0,9067
Adjusted R Square	0,9017
Standard Error	485,7498
Observations	120,0000

ANOVA

	df	*SS*	*MS*	*F*
Regression	6,0000	259118182,4754	43186363,7459	183,0296
Residual	113,0000	26662673,4496	235952,8624	
Total	119,0000	285780855,9250		

	Coefficients	*Standard Error*	*t Stat*	*Lower 95%*	*Upper 95%*
Intercept	-989,6963	635,2876	-1,5579	-2248,3155	268,9230
Reproduction rate	490,1287	624,9004	0,7843	-747,9117	1728,1691
ICU patients	3,3670	1,7817	1,8898	-0,1628	6,8969
Hosp patients	-1,2745	0,3472	-3,6705	-1,9624	-0,5866
New tests	0,0075	0,0027	2,7540	0,0021	0,0129
Positive rate	65851,5967	7034,0015	9,3619	51915,9710	79787,2223
Fully vaccinated people	0,0000	0,0002	0,2065	-0,0003	0,0003

New cases = -989.6963 + 490.1287 (reproduction rate) + 3.3670 (ICU patients) - 1.2745 (Hosp patients) + 0.0075 (new tests) + 65851.5967 (positive rate) + 3.1877E-05 (Fully vaccinated people)

The reproduction rate, ICU patients, new tests, positive rate, and fully vaccinated people - coefficients in the regression equation are respectively 490.1287, 3.3670, 0.0075, 65851.5967, 3.1877E-05. Those coefficients represent the mean increase of new cases for every additional increase in reproduction rate, ICU patients, new tests, positive rate, or fully vaccinated people. If the reproduction rate, ICU patients, new tests, positive rate, or fully vaccinated people coefficients increase by 1, the average new cases increase respectively by 490.1287, 3.3670, 0.0075, 65851.5967 or 3.1877E-05.

The Hosp patients coefficient in the regression equation is -1.2745. This coefficient represents the mean decrease of new cases for every additional increase in Hosp patients. If the Hosp patients increase by 1, the average new cases decrease by -1.2745.

6 – New Deaths

Regression Statistics	
Multiple R	0,9939
R Square	0,9879
Adjusted R Square	0,9872
Standard Error	7,5058
Observations	120,0000

ANOVA

	df	*SS*	*MS*	*F*
Regression	6,0000	518068,5140	86344,7523	1532,6481
Residual	113,0000	6366,0776	56,3370	
Total	119,0000	524434,5917		

	Coefficients	*Standard Error*	*t Stat*	*Lower 95%*	*Upper 95%*
Intercept	-7,7337	9,8165	-0,7878	-27,1819	11,7145
Reproduction rate	-2,5517	9,6559	-0,2643	-21,6819	16,5785
ICU patients	-0,0792	0,0275	-2,8784	-0,1338	-0,0247
Hosp patients	0,0239	0,0054	4,4522	0,0133	0,0345
New tests	0,0000	0,0000	0,9097	0,0000	0,0001
Positive rate	885,1222	108,6892	8,1436	669,7892	1100,4552
Fully vaccinated people	0,0000	0,0000	0,1684	0,0000	0,0000

New deaths = = -7.7337 - 2.5517 (reproduction rate) - 0.079 (ICU patients) + 0.0239 (Hosp patients) + 3.8375E-05 (new tests) + 885.1222 (positive rate) + 4.0169E-07 (fully vaccinated people)

The Hosp patients, new tests, positive rate, and fully vaccinated people coefficients in the regression equation are respectively 0.0239, 3.8375E-05, 885.1222, 4.0169E-07. Those coefficients represent the mean increase of new deaths for every additional increase in Hosp patients, new tests, positive rate, or fully vaccinated people. If the Hosp patients, new tests, positive rate, or fully vaccinated people coefficients increase by 1, the average new deaths increase respectively by 0.0239, 3.8375E-05, 885.1222 or 4.0169E-07.

The reproduction rate and ICU patients coefficients in the regression equation are respectively -2.5517 and -0.079. Those coefficients represent the mean decrease of new deaths for every additional increase in reproduction rate or ICU patients. If the reproduction rate or ICU patients increase by 1, the average new deaths decrease respectively by -2.5517 or -0.079.

3 – New Cases

Regression Statistics	
Multiple R	0,9482
R Square	0,8991
Adjusted R Square	0,8965
Standard Error	498,4592
Observations	120,0000

ANOVA

	df	*SS*	*MS*	*F*
Regression	3,0000	256959318,0326	85653106,0109	344,7339
Residual	116,0000	28821537,8924	248461,5336	
Total	119,0000	285780855,9250		

	Coefficients	*Standard Error*	*t Stat*	*Lower 95%*	*Upper 95%*
Intercept	-35,6094	101,1282	-0,3521	-235,9066	164,6878
ICU patients	0,9148	1,2705	0,7200	-1,6016	3,4312
Hosp patients	-0,9307	0,3223	-2,8875	-1,5691	-0,2923
Positive rate	63617,1574	6915,2939	9,1995	49920,5464	77313,7684

New cases = -35.6094 + 0.9148 (ICU patients) - 0.9307 (Hosp patients) + 63617.1574 (positive rate)

The ICU patients and positive rate coefficients in the regression equation are respectively 0.9148 and 63617.1574. Those coefficients represent the mean increase of new cases for every additional increase in ICU patients or positive rate. If your ICU patients or positive rate coefficients increase by 1, the average new cases increase respectively by 0.9148 or 63617.1574.

The Hosp patients coefficient in the regression equation is - 0.9307. This coefficient represents the mean decrease of new cases for every additional increase in Hosp patients. If the Hosp patients increase by 1, the average new cases decrease by - 0.9307.

3 – New Deaths

Regression Statistics	
Multiple R	0,9939
R Square	0,9878
Adjusted R Square	0,9875
Standard Error	7,4359
Observations	120,0000

ANOVA

	df	*SS*	*MS*	*F*
Regression	3,0000	518020,5937	172673,5312	3122,8775
Residual	116,0000	6413,9979	55,2931	
Total	119,0000	524434,5917		

	Coefficients	*Standard Error*	*t Stat*	*Lower 95%*	*Upper 95%*
Intercept	-8,1263	1,5086	-5,3866	-11,1143	-5,1383
ICU patients	-0,0818	0,0190	-4,3167	-0,1194	-0,0443
Hosp patients	0,0248	0,0048	5,1508	0,0152	0,0343
Positive rate	867,1734	103,1612	8,4060	662,8496	1071,4972

New deaths = -8.1263 - 0.0818 (ICU patients) + 0.0248 (Hosp patients) + 867.1734 (positive rate)

The Hosp patients and positive rate coefficients in the regression equation are respectively 0.0248 and 867.1734. Those coefficients represent the mean increase of new deaths for every additional increase in Hosp patients or positive rate. If the Hosp patients or positive rate coefficients increase by 1, the average new deaths increase respectively by 0.0248 or 867.1734.

The ICU patients coefficient in the regression equation is -0.0818. This coefficient represents the mean decrease of new deaths for every additional increase in ICU patients. If the ICU patients increase by 1, the average new deaths decrease by -0.0818.

Annex B – MDISC

Evaluation of the effectiveness of the vaccination center’s response

Introduction

In the application, there is an option to evaluate the effectiveness of the vaccination center’s response; its goal is to decrease the number of clients in the center, from the moment they register at the arrival until the moment they receive the SMS informing they can leave the vaccination center.

To do that, we implemented a brute force algorithm that, for a specific day and time intervals of *m* minutes, chosen by the center coordinator, with a daily work from 8 a.m. to 8 p.m., the procedure creates a list of length 720/*m*, where the *i*-th value of the list is the difference between the number of new clients arriving and the number of clients leaving the center in that *i*-th time interval.

```
procedure maxContiguousSum (i: integer, j: integer, k: integer, n:integer ,
seq[1], seq[2],..., seq[i]: integer, copy[1],copy[2],...,copy[i]: integer)

      start := 0
      end := 0
      max := -9999
      currentSum := 0
      for i := 0 to n do
            for j := 0 to i-1 do
                  for k := 0 to j do
                        currentSum := currentSum + seq[k]
                  end for
                  if currentSum > max
                  then max := currentSum
                       start := i
                       end := j
                  end if
                  currentSum := 0
            end for
      end for
      copy[0] := start
      copy[1] := end
      return copy
end procedure
```

Algorithm 1- Brute force algorithm's pseudocode

```
procedure maxContiguousSum (i: integer, seq[1], seq[2],..., seq[i]:
integer,copy[1],copy[2],...,copy[i]: integer)

      maxSoFar:= 0
      maxEndingHere:= 0
      startMaxSoFar:= 0
      endMaxSoFar:= 0
      startMaxEndingHere:= 0
      while i < length(seq)
            elem:= seq[i]
            endMaxEndingHere:= i + 1
            if maxEndingHere + elem < o
            then maxEndingHere:= 0
                 startMaxEndingHere:= i + 1
            else maxEndingHere:= maxEndingHere + elem
            if maxSoFar < maxEndingHere
            then maxSoFar:= maxEndingHere
                 starMaxSoFar:= startMaxEndingHere
                 endMaxSoFar:= endMaxEndingHere
            end if
```

```
            ++i
      return copyArray(seq, copy)
end procedure

 procedure copyArray(x: integer, A[1], A[2],..., A[]: integer, B[1],
B[2],..., B[]: integer)

      for x:= 0 to x do
          B[x] := A[x]
          x := x + 1
end procedure
```

Algorithm 2- Benchmark algorithm's pseudocode

Runtime tests

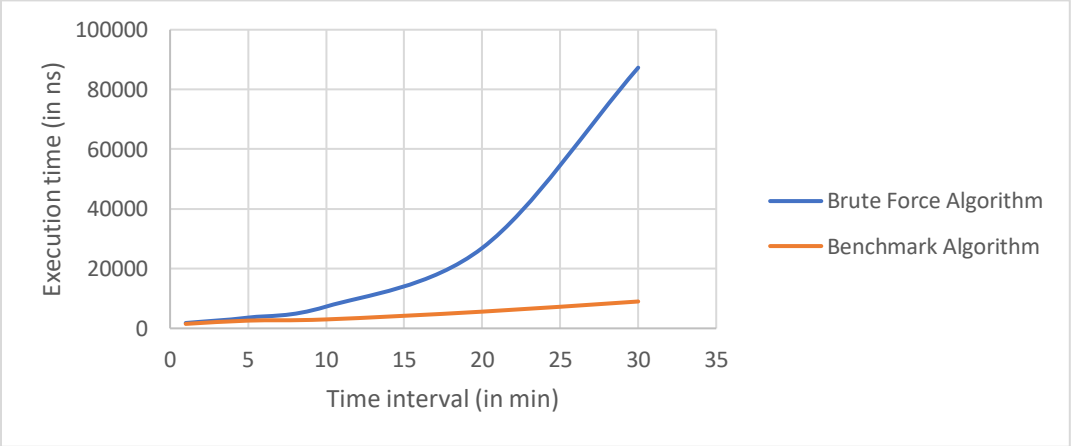


Chart 1- Brute force algorithm and the benchmark algorithm's runtime tests

Worst-case time analysis

Line	Operation	Time complexity
1	start:= 0	O(1)
2	end:= 0	O(1)
3	max:= -9999	O(1)
4	currentSum:= 0	O(1)
5	currentSum := currentSum + seq[k]	$O(\frac{n(n-1)^2}{2})$
6	max := current sum	$O(\frac{n(n-1)}{2})$
7	start := i	$O(\frac{n(n-1)}{2})$

8	end := j	O($\frac{n(n-1)}{2}$)
9	currentSum := 0	O($n(n-1)$)
10	copy[0] := start	O(1)
11	copy[1] := end	O(1)
12	return copy	O(1)

By simplifying the time complexity of line 9, we get the worst-case time complexity of $O(n^3)$, being n the number of inputs.

Sorting clients by arrival time, or by leaving time

Introduction

The application has an option to import legacy systems that were used in the past to manage centers and then sort their data by arrival time or leaving time. To accomplish that, we use two different sorting algorithms: Bubble sort and Quick sort.

Bubble sort consists of swapping two adjacent elements if they are in the wrong order, while quick sort first selects any element as the pivot, then it partitions the elements into two sub-arrays, one being lower than the pivot and the other higher, and then sort them in the correct order; this process repeats until the intended order is obtained.

```
procedure bubble sort(n:integer, A[0], A[1],..., A[n]: integer)
    n := length(A)
    for i := 0 to n do
      for j := 0 to (n-i) do
          if A[j] > A[j+1]
          then swap(A, j, j+1)
          end if
      end for
end procedure

procedure swap(arr[1], arr[2],..., arr[i]: integer, i: integer, j: integer)
    temp := arr[i]
    arr[i] := arr[j]
    arr[j] := temp
    return arr
end procedure
```

Algorithm 3- Bubble sort algorithm in pseudocode

```
procedure quick sort(arr[1],arr[2],...,arr[pivot]: integer, low: integer,
high: integer)
    if (low < high)
        pivot = partition(arr, low, high);
        quick sort(arr, low, pivot - 1)
        quick sort(arr, pivot + 1, high)
```

```
    end if
    return arr
end procedure


procedure partition (i: integer, arr[1], arr[2],..., arr[i]: integer, low:
integer, high: integer)
      pivot := arr[high]
      i := (low - 1)
      for j := low to (high - 1) do
          if (arr[j] < pivot)
          then i++
              swap(arr, i, j)
          end if
      end for
      swap(arr, i+1, high)
      return (i + 1)
end procedure

procedure swap(arr[1], arr[2],..., arr[i]: integer, i: integer, j: integer)
    temp := arr[i]
    arr[i] := arr[j]
    arr[j] := temp
    return arr
end procedure
```

Algorithm 4- Quick sort algorithm and its methods in pseudocode

Runtime tests

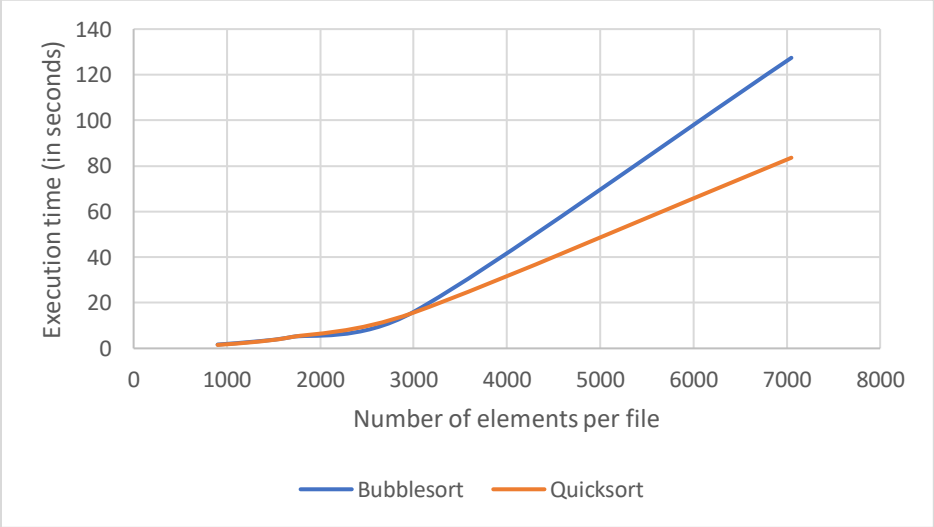


Chart 2- Bubble sort and Quick sort runtime tests by arrival time

Worst-case time analysis

Bubble sort

Line	Operation	Time complexity
- bubble sort()		
1	n := length(A)	O(1)
2	swap(A[j],A[j+1])	O(n(n-1))
-swap()		
3	temp:= arr[i]	O(1)
4	arr[i]:= arr[j]	O(1)
5	arr[j]:= temp	O(1)
6	return arr	O(1)

The operation in line 2 hast the highest time complexity, therefore the Bubble sort algorithm has a worst-case time complexity of O(n^2), being *n* the number of inputs.

Quick sort

Line	Operation	Time complexity
- quick sort()		
1	pivot = partition(arr, low, high)	O(n)
2	quick sort(arr, low, pivot – 1)	O($\frac{n^2}{2}$)
3	quick sort(arr,pivot + 1, high)	O($\frac{n^2}{2}$)
4	return arr	O(1)
- partition()		
5	pivot := arr[high]	O(1)
6	i := (low -1)	O(1)
7	i++	O(n)
8	swap (arr, i, j)	O(n)
9	swap(arr, i+1, high)	O(1)
10	return(i+1)	O(1)
- swap()		
11	temp := arr[i]	O(1)
12	arr[i] := arr[j]	O(1)
13	arr[j] := temp[i]	O(1)
14	return arr	O(1)

The lines 2 and 3 have the highest time complexity, therefore the Quick sort algorithm has a worst-case time complexity of O(n^2), being *n* the number of inputs.