

# MANUAL

## COVID-19 Forecast Tool

COVID-19 GLOBAL RESPONSE

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With support of



For more information regarding the use of this product, please contact the 510 Data Team by sending an email to [support@510.global](mailto:support@510.global)

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## Introduction

Since March 2020, the 510 Data Team of the Netherlands Red Cross (NLRC) has aided various National Societies (NS) by providing a tool that estimates future cases and Intensive Care Unit (ICU) admissions due to the development of COVID-19 as result of being infected by the SARS-CoV-2 virus. This manual provides the information that one needs to know when planning on using this tool.

### Product in a nutshell

The tool presented in this manual uses a programming script, publicly available data on COVID-19 cases and a cloud computing service to automatically collect COVID-19 data and estimate the future cases and ICU admissions due to COVID-19.

### What is the COVID-19 Forecast Tool and what can you do with it?

The 510 Data Team used the COVID-19 Forecast Tool to estimate new cases and new ICU admissions due to COVID-19, thereby supporting the Palestine Red Crescent Society. The framework consists of the cloud computing service Azure Functions which runs a Python script at set times. This results in the following:

1. Collection of current COVID-19 case numbers published by the Palestinian government.
2. Collection of the predicted national COVID-19 numbers published by the Medical Research Council (MRC) Centre for Global Infectious Disease Analysis of the Imperial College London (ICL) and calculated based on a SEIR model<sup>1</sup>.
3. The subsequent calculation of the predicted cases and ICU admissions at a governorate level and production of graphs depicting the result.

We could like to note that although the current forecasting system has been set up in Azure Functions, one could also forecast COVID-19 without using Azure Functions, by running the relevant script locally. These two options are shown in the section “Setting up the COVID-19 Forecast Tool: a step-by-step guide”.

### Who is the COVID-19 Forecast Tool for?

The Forecast Tool can be used by any NS or other non-governmental organisation looking to quickly estimate the upcoming cases of COVID-19 and organize their response and healthcare system capacity. Until now the 510 data team has aided the Palestine Red

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<sup>1</sup> For more information on the short-term forecast ICL tool see <https://mrc-ide.github.io/covid19-short-term-forecasts/index.html>

Crescent Society in the prediction of the upcoming COVID-19 cases at a governorate level. By using a similar framework (see section “Previous efforts on COVID-19 forecasting”), the 510 Data Team has also responded to the needs of the Nepal Red Cross Society and the Lebanese Red Cross.

### **Why use COVID-19 Forecast Tool?**

The COVID-19 Forecast Tool offers a fast and automated way of estimating upcoming cases and ICU admissions related to COVID-19. The Forecast Tool can help non-governmental organizations with fast decision-making and response to possible scenarios.

### **Why run the COVID-19 Forecast Tool in Azure Functions?**

Azure Functions allow the user to run the forecast in an automated way on the cloud, in chosen time intervals, which translates to minimal effort and time investment from the moment the system is set up. What’s more, the system offers reliability by ensuring the forecasting is not interrupted and does not make use of a local computer. Please note that there are costs tied to the use of Azure Functions. For more information, please refer to the section “Requirements: cost”.

### **Previous efforts on COVID-19 forecasting**

It is worth mentioning that at the time of the COVID-19 global outbreak, the ICL model which estimates future COVID-19 cases and ICU entries had not yet been developed. The 510 Data Team therefore initially responded to the need of the Nepal Red Cross Society and the Lebanese Red Cross for COVID-19 estimation by modifying and using a different model, developed by TNO, the Netherlands Organization for applied scientific research. Within the TNO COVID-19 prediction framework the model parameters can be customized, however the user needs to compute the predictions themselves.

On the other hand, the ICL framework uses predefined settings that are widely applicable and the predictions are executed by ICL itself, which means that it needs minimal computing space from the user. Therefore, we strongly recommend using the ICL-based framework presented in this manual, unless the situation of the country requires very specific parameters to be taken into account. For more information about the TNO-based framework that the 510 Data Team developed during the early COVID-19 response, please refer to <https://github.com/rodekruis/Covid-SEIR>.

## Case study

The COVID-19 Forecast Tool is useful for estimating future COVID-19 cases in a country at both national and subnational (governorate) levels. For the case of the Occupied Palestinian Territory (OPT), the ICL framework was used.

The framework uses COVID-19 data that have been registered and published by the government as well as predicted numbers published by ICL. The model also factors in hospitalization cases and the ICU needs. Additionally, the SEIR model has been adapted to take into account the effects of social distancing thereby reducing the reproduction number. The main advantage of such a tool is that it can be adapted to fit any country profile and can be used to predict other epidemiological trends post COVID-19.

In OPT, the Red Crescent Society is using the tool to help in their preparedness response. The output data helps the Red Crescent communicate and coordinate with its branches on potential rise of cases in the next weeks. This way, the teams can prepare themselves with protective equipment and assure the availability of ambulances.

## Data responsibility

### Datasets

The COVID-19 Forecast Tool uses publicly available data on COVID-19, which include the number of cases recorded on a national and governorate level, as well as hospitalization and ICU admittance. Data on the cases could be found on the respective government websites that publishes the relevant information, whereas data on predicted national cases could be found on the ICL website.

### Data processing

The data could be processed in two ways: 1) manually and locally by using a programming script, or 2) automatically and cloud-based in which case data is collected and processed using a cloud computing service. The data processed will help NS predict upcoming COVID-19 cases in order to take appropriate preparedness measures.

### Non-discrimination

The tool is non-discriminatory.

### Human oversight

The tool depends on human involvement for the development of the programming script and the allocation of the appropriate resources to extract data from. The final output will be evaluated by the end user who will base any future decision on the results. The end user will indicate if any preparedness measures are needed and at what locations based on the final output of the COVID-19 Forecast Tool.

### Risks

The end user will need to understand 1) what data was being used for the COVID-19 Forecast Tool and 2) what the output presents. The data on COVID-19 cases that are published on government websites are not always accurate. Additionally, there is a potential that the predicted from ICL could be overestimating cases, which might not be representative at the NS level.

## Requirements

### User knowledge

In this section we describe the skills that someone would need to use the COVID-19 Forecast Tool presented in this manual. In addition to the skills mentioned below, it is crucial the user has the following skills:

- Analytical thought
- Problem-solving attitude

### Required skills for setting up and using the COVID-19 Forecast Tool

To collect and analyze COVID-19 case data the user will need the following skills:

- **Python:** it is necessary that the user has knowledge and experience with Python to execute the API and run the Python scripts and adjust them if needed.
- **Microsoft Azure Functions (for Function App option):** it is desirable that the user has knowledge and experience with Microsoft Azure Functions (if planning on running the script through Azure).
- **Visual Studio Code (for Function App option):** it is desirable that the user has knowledge of Visual Studio Code.
- **Microsoft Teams SharePoint (for Function App option):** it is desirable that the user has knowledge and experience with Microsoft Teams SharePoint.

### Hardware

Below you can find the hardware requirements for the COVID-19 Forecast Tool explained in this manual.

- **Python** (versions: 3.6.X):
  - Processor: Intel Atom® processor or Intel® Core™ i3 processor
  - Disk space: 1 GB
  - Operating systems: Windows\* 7 or later, macOS, or Linux
- **Microsoft Azure:**
  - Processor: 1 (for express environment); 2 (for distributed environment)
  - RAM: 8GB (don't use dynamic memory)
  - Disk Space: 40 GB
  - Operating system: Windows, Linux

- **Visual Studio Code:**

- Processor: 1.6 GHz or faster
- RAM: 1 GB
- Operating System: Windows 7 or later, OS X Yosemite (10.10+), Linux
- .NET version (for windows): Microsoft .NET Framework 4.5.2 is required

- **Microsoft Teams:**

On a windows computer:

- Processor: minimum 1.6 GHz (or higher), 2 cores
- RAM: 4 GB
- Disk space: 3 GB
- Display: 1024 x 768 screen resolution
- Graphics: Windows OS: Graphics hardware acceleration requires DirectX 9 or later, with WDDM 2.0 or higher for Windows 10 (or WDDM 1.3 or higher for Windows 10 Fall Creators Update)
- Operating system: Windows 10, Windows 10 on ARM, Windows 8.1, Windows Server 2019, Windows Server 2016
- .NET version: Requires .NET 4.5 CLR or later

On a Mac:

- Processor: Intel Core Duo processor
- RAM: 4.0 GB
- Disk space: 1.5 GB
- Display: 1280 x 800 or higher resolution
- Operating system: One of the three most recent versions of macOS.

## Software

Below we list the software required for the COVID-19 Forecast Tool explained in this manual.

- Internet browser (for computers) such as
  - Mozilla Firefox  
[www.mozilla.org/en-US/firefox/new/](http://www.mozilla.org/en-US/firefox/new/)
  - Google Chrome  
[www.google.com/chrome/](http://www.google.com/chrome/)
- Installed Python  
<https://www.python.org/>
- Microsoft Azure Functions (for Azure Function option)  
<https://azure.microsoft.com/en-us/services/functions/>



- Visual Studio Code (for Azure Function option)  
<https://code.visualstudio.com/>
- Microsoft Teams (for Azure Function option)  
<https://www.microsoft.com/en-ww/microsoft-teams/download-app>

## Time

Here we indicate which parameters influence the duration of usage of the COVID-19 Forecast Tool, and state a real-life example of usage by a NS.

For reference, the 510 Data Team of the NLRC spent approximately 80 hours to set up the COVID-19 forecaster (both in Azure Function and for local run) and it takes about 2 minutes to run.

## Costs

Here we indicate which parameters influence the costs of usage of the COVID-19 Forecast Tool.

The usage of Azure Functions is tied to a price per month the amount of which depends on the per-second time resource consumption and execution, which for the Azure Functions usage in this manual, add up to a relatively low cost<sup>2</sup>. For more information, please refer to <https://azure.microsoft.com/en-us/pricing/details/functions/>.

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<sup>2</sup> The total cost of using the Azure Function for the COVID-19 Forecast Tool described in this manual, amounts to ± 2 USD as of March 31<sup>st</sup> 2021.

## The product

### What does the COVID-19 Forecast Tool consist of?

The prediction of future COVID-19 cases and ICU admissions can be achieved by using either of the two following options:

1. By running the Python scripts with Azure Functions
  - Microsoft Azure Functions
  - Python scripts (including Azure Functions setup)
  - COVID-19 case predictions computed by the MRC Centre for Global Infectious Disease Analysis, Imperial College London ICL
  - COVID-19 case numbers published by the OPT government
  
2. By running the Python scripts locally
  - Python scripts (to run locally)
  - COVID-19 case predictions computed by the MRC Centre for Global Infectious Disease Analysis, ICL
  - COVID-19 case numbers published by the OPT government

### Locations to download the product

Here we provide the links and locations to find the tools needed to set up and use the COVID-19 Forecast Tool.

- Microsoft Azure  
<https://azure.microsoft.com/en-us/>
- Github page for forecasting COVID-19 by using Python with Azure functions  
<https://github.com/rodekruis/covid-forecast-opt-function-app>
- Github page for forecasting COVID-19 by using Python without Azure functions  
<https://github.com/rodekruis/covid-forecast-opt>

### Advantages & Limitations

There are several advantages and limitations linked to using the ICL-based COVID-19 Forecast Tool. Here we briefly discuss these.

- The user depends on access to the Microsoft products Azure and Teams (if the Azure platform is used).

- The user depends on the predicted data that is outputted by the MRC Centre for Global Infectious Disease Analysis, ICL.
- The pipeline described in this manual requires expertise in Python to setup, which could be a limitation if there is no expert present in the organization, although less Python experience is needed to run the pipeline once it is set up.

## Using the COVID-19 Forecast Tool: a step-by-step guide

The COVID-19 Forecast Tool has been set up by the NLRC 510 Data Team to run in an automated manner by the cloud-computing service Azure. However, this is not a prerequisite to forecast COVID-19 cases and ICU entries; the Python script calculating these numbers can also be run locally. In this section of the manual, we briefly describe the major steps of this Python script and showcase the output of a particular time point.

### 1. Create a function in Azure with Python using Visual Studio Code (Optional)

To run the script automatically at set times, we recommend using an Azure function app which is based on the Azure cloud computing service. To build a function in Azure using Python, follow the readily available documentation:

- <https://github.com/jmargutt/azure-python-function-app>
- <https://docs.microsoft.com/en-us/azure/azure-functions/create-first-function-vs-code-python>

### 2. Run the Python script using Azure functions or run it locally

If your system is set up to run on Azure, use the Python `script_init.py` (corresponding documentation and additional necessary files: <https://github.com/rodekruis/covid-forecast-palestine-function-app>). If, instead, you do not make use of Azure functions but wish to run the forecast locally, use the script `covid_process.py` (corresponding documentation and additional necessary files: <https://github.com/rodekruis/covid-forecast-palestine>).

Besides their differences in the location in which the scripts are executed, both consist of the same main steps, which we will describe in brief below:

- a. Collection of latest corona case numbers from the government website (or other website source). The script written for OPT obtains this data from [www.corona.ps](http://www.corona.ps) and uses a google API to translate the information from Arabic to English. The obtained data frame contains case numbers per governorate and is saved in the format `COVID_ps_[date].csv` where `[date]` is the date of execution (**Figure 1**).

	Governorate	The number of cases	Cases today	Active cases	recovery cases	Death cases
1	Jericho	3,06	18	175	2,86	25
2	Hebron	28,558	136	897	27,315	346
3	Suburbs of Jerusalem	7,487	18	509	6,915	63
4	Bethlehem	11,294	94	792	10,372	130
5	Jenin	10,25	62	329	9,743	178
6	Ramallah and Al-Bireh	17,709	191	1,686	15,825	198
7	Salfit	4,069	75	598	3,438	33
8	Tubas	2,645	17	57	2,556	32
9	Tulkarm	7,808	33	383	7,312	113
10	Gaza strip	53,593	79	2,551	50,505	537
11	Qalqilya	4,46	27	327	4,063	70
12	Nablus	17,511	90	999	16,301	211
13	City of Jerusalem	21,872	208	1,406	20,269	197

**Figure 1** • The shown data are collected from the OPT government site. The csv file is opened in Microsoft Excel.

- b. Collection of latest case predictions from the Github page of MRC Centre for Global Infectious Disease Analysis at ICL. The script written for OPT obtains this data from <https://github.com/mrc-ide/global-lmic-reports>, and in particular by reading the file `forecast_latest.csv`, which contains the estimated numbers of cases and ICU entries, amongst others, for the next 28 days (**Figure 2**).

date	compartment	y_025	y_25	y_median	y_mean	y_75	y_975	scenario	country	iso3c	report_date	version	death_calibrated
04/07/2020	cumulative_deaths	10.48	17	23	24.17	29	44.52	Surged Relax Interventions 50%	State of Palestine	PSE	30/01/2021	v7	TRUE
04/07/2020	cumulative_infections	6144.42	16655.25	22291.5	23571.01	28764	47036.35	Surged Relax Interventions 50%	State of Palestine	PSE	30/01/2021	v7	TRUE
04/07/2020	deaths	1	1	1	1.79	2	5	Surged Relax Interventions 50%	State of Palestine	PSE	30/01/2021	v7	TRUE
04/07/2020	hospital_demand	14.48	50	71.5	73.4	90.25	146.2	Surged Relax Interventions 50%	State of Palestine	PSE	30/01/2021	v7	TRUE
04/07/2020	hospital_incidence	1.48	7	11	10.57	14	21.1	Surged Relax Interventions 50%	State of Palestine	PSE	30/01/2021	v7	TRUE
04/07/2020	ICU_demand	6.9	18.75	26	26.39	32	55.1	Surged Relax Interventions 50%	State of Palestine	PSE	30/01/2021	v7	TRUE
04/07/2020	ICU_incidence	0	2	3	3.04	4	7.52	Surged Relax Interventions 50%	State of Palestine	PSE	30/01/2021	v7	TRUE
04/07/2020	infections	281.95	865.75	1157.5	1186.6	1425.5	2266.62	Surged Relax Interventions 50%	State of Palestine	PSE	30/01/2021	v7	TRUE
04/07/2020	prevalence	2008.7	6085.75	8132.5	8332.73	10006.5	16340.72	Surged Relax Interventions 50%	State of Palestine	PSE	30/01/2021	v7	TRUE
04/07/2020	Rt	1.16	1.25	1.29	1.29	1.33	1.4	Surged Relax Interventions 50%	State of Palestine	PSE	30/01/2021	v7	TRUE
04/07/2020	Reff	1.15	1.24	1.28	1.28	1.32	1.39	Surged Relax Interventions 50%	State of Palestine	PSE	30/01/2021	v7	TRUE
05/07/2020	cumulative_deaths	11	21	25	25.81	30	44.05	Additional 50% Reduction	State of Palestine	PSE	30/01/2021	v7	TRUE
05/07/2020	cumulative_infections	7032.02	20258.5	24408.5	25627.06	31577	48961.57	Additional 50% Reduction	State of Palestine	PSE	30/01/2021	v7	TRUE
05/07/2020	deaths	1	1	2	1.97	3	4	Additional 50% Reduction	State of Palestine	PSE	30/01/2021	v7	TRUE
05/07/2020	hospital_demand	23	59.75	79.5	80.03	100.5	149.2	Additional 50% Reduction	State of Palestine	PSE	30/01/2021	v7	TRUE
05/07/2020	hospital_incidence	2	8	10	10.65	13	24.05	Additional 50% Reduction	State of Palestine	PSE	30/01/2021	v7	TRUE
05/07/2020	ICU_demand	7.47	21	29	28.88	36	51.05	Additional 50% Reduction	State of Palestine	PSE	30/01/2021	v7	TRUE
05/07/2020	ICU_incidence	0	2	3	3.27	5	7	Additional 50% Reduction	State of Palestine	PSE	30/01/2021	v7	TRUE
05/07/2020	infections	360.2	951.5	1179.5	1247.43	1545.75	2311.07	Additional 50% Reduction	State of Palestine	PSE	30/01/2021	v7	TRUE
05/07/2020	prevalence	2608.6	6674.25	8230.5	8770.48	10988.25	16501.7	Additional 50% Reduction	State of Palestine	PSE	30/01/2021	v7	TRUE
05/07/2020	Rt	1.14	1.23	1.27	1.27	1.31	1.39	Additional 50% Reduction	State of Palestine	PSE	30/01/2021	v7	TRUE
05/07/2020	Reff	1.14	1.22	1.26	1.26	1.3	1.38	Additional 50% Reduction	State of Palestine	PSE	30/01/2021	v7	TRUE
05/07/2020	cumulative_deaths	11	21	25	25.81	30	44.05	Maintain Status Quo	State of Palestine	PSE	30/01/2021	v7	TRUE
05/07/2020	cumulative_infections	7032.02	20258.5	24408.5	25627.06	31577	48961.57	Maintain Status Quo	State of Palestine	PSE	30/01/2021	v7	TRUE
05/07/2020	deaths	1	1	2	1.97	3	4	Maintain Status Quo	State of Palestine	PSE	30/01/2021	v7	TRUE
05/07/2020	hospital_demand	23	59.75	79.5	80.03	100.5	149.2	Maintain Status Quo	State of Palestine	PSE	30/01/2021	v7	TRUE
05/07/2020	hospital_incidence	2	8	10	10.65	13	24.05	Maintain Status Quo	State of Palestine	PSE	30/01/2021	v7	TRUE
05/07/2020	ICU_demand	7.47	21	29	28.88	36	51.05	Maintain Status Quo	State of Palestine	PSE	30/01/2021	v7	TRUE
05/07/2020	ICU_incidence	0	2	3	3.27	5	7	Maintain Status Quo	State of Palestine	PSE	30/01/2021	v7	TRUE
05/07/2020	infections	360.2	951.5	1179.5	1247.43	1545.75	2311.07	Maintain Status Quo	State of Palestine	PSE	30/01/2021	v7	TRUE
05/07/2020	prevalence	2608.6	6674.25	8230.5	8770.48	10988.25	16501.7	Maintain Status Quo	State of Palestine	PSE	30/01/2021	v7	TRUE
05/07/2020	Rt	1.14	1.23	1.27	1.27	1.31	1.39	Maintain Status Quo	State of Palestine	PSE	30/01/2021	v7	TRUE
05/07/2020	Reff	1.14	1.22	1.26	1.26	1.3	1.38	Maintain Status Quo	State of Palestine	PSE	30/01/2021	v7	TRUE

**Figure 2** • The shown data are collected from the Github page of MRC Centre for Global Infectious Disease Analysis at ICL. The csv file is opened in Microsoft Excel.

It is important to note that the ICL estimations are made based on the reported number of deaths. The extent to which reported deaths capture the true mortality is unclear, and will vary from one country to another<sup>3</sup>.

### c. Calculation of the forecast numbers

For the forecast, the data from the column “Cases today” are used from the `COVID_ps_[date].csv` file. The country sum is calculated by summing the new cases of all governorates (*gov*).

$$country\ sum = \sum new\ cases_{gov\ i}$$

The script then calculates the weight of each governorate (proportion).

$$proportion_{gov\ i} = \frac{new\ cases_{gov\ i}}{country\ sum}$$

Next, the script extracts the infections and ICU incidence data from the column “compartments” from the `forecast_latest.csv` file, which are predicted for the scenario where the current country restrictions are maintained (“surged maintain status quo”). Only data predicted for the upcoming 7 days are used, and other parameters such as the median measurement are defined. The ICL data are calculated nation-wide. To calculate the predictions (either new infections or ICU incidents) for each governorate, the following calculation is made:

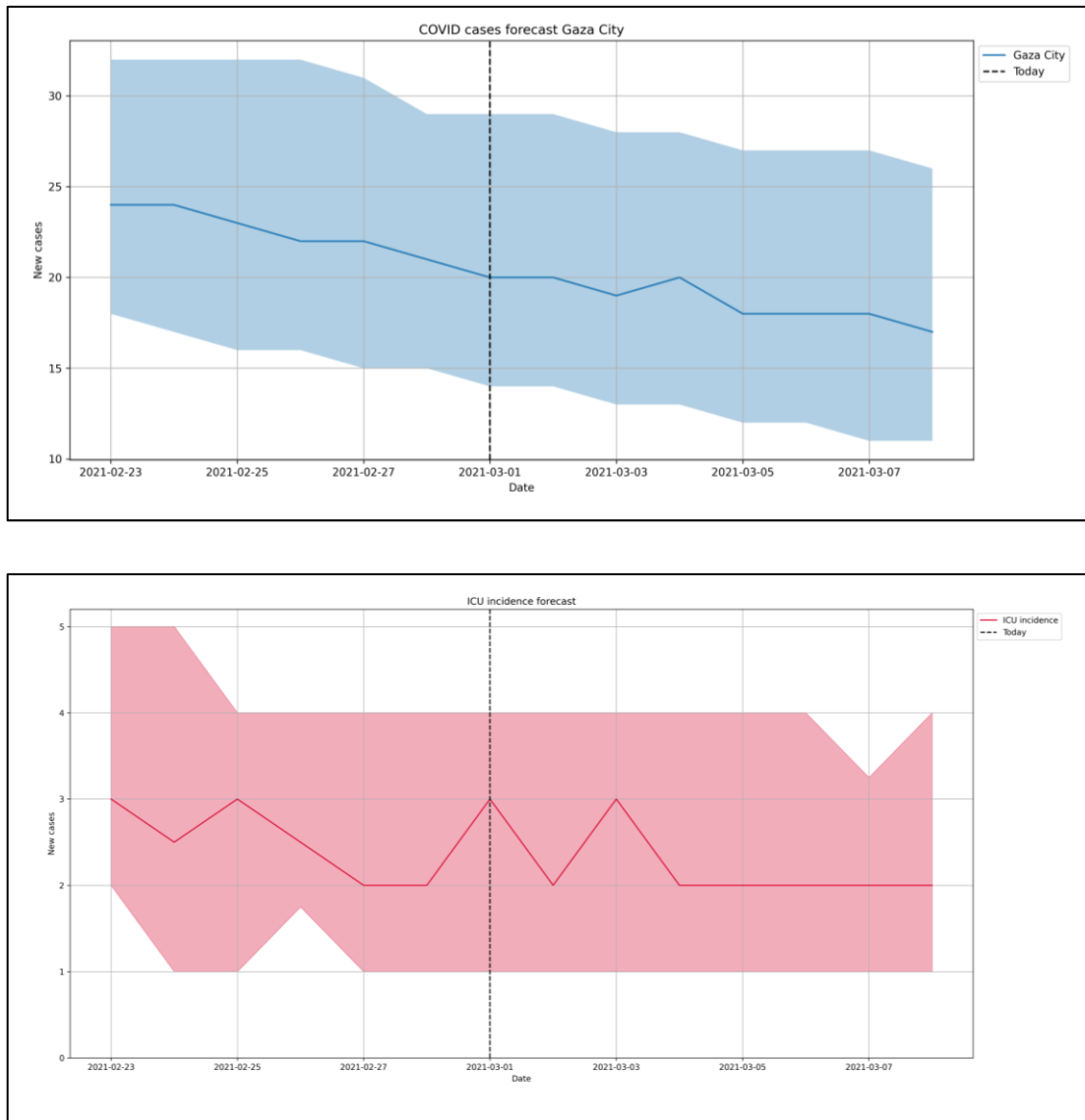
$$forecast_{gov\ i} = forecast_{ICL} \times proportion_{gov\ i}$$

Furthermore, the script calculates the forecast per Gaza strip governorates from the total forecasted numbers for the Gaza strip (see script).

### d. Output

Next, the Python script creates plots that visualize the forecasted new cases and ICU entries, saved as `[date]_covid_forecast.png` and `[date]_ICU_forecast.png`, respectively (**Figure 3**). The script also saves the predicted numbers for the cases and ICU incidents in separate csv files named `[date]_covid_forecast.csv` and `[date]_ICU_forecast.csv`. If the Python script is run through Azure, the figures and files are stored in Microsoft Teams.

<sup>3</sup> For more information, see <https://mrc-ide.github.io/global-lmic-reports/FAQ.html>.



**Figure 3** • Predicted new cases (upper panel) and new ICU incidents (lower panel) as predicted by the Forecast Tool, for the governorate Gaza city. Data for + and - 1 week from the date indicated by the vertical dotted line are shown. The bold line indicates the mean, whereas the shaded area indicates the confidence intervals

## Abbreviations

NLRC	The Netherlands Red Cross
NS	National Society/Societies
ICU	Intensive Care Unit
SARS-CoV-2	Severe Acute Respiratory Syndrome coronavirus 2
COVID-19	The disease caused by the SARS-CoV-2 virus
ICL	Imperial College London
MRC	Medical Research Council
OPT	Occupied Palestinian Territory
API	Application Programming Interface

## Resources

- <https://github.com/rodekruis/Covid-SEIR>
- Methods of the ICL model  
<https://github.com/mrc-ide/squire>
- <https://mrc-ide.github.io/global-lmic-reports/parameters.html>
- Occupied Palestinian Territory government site reporting COVID-19 cases  
<https://corona.ps/>
- The ICL prediction tool website  
<https://mrc-ide.github.io/covid19-short-term-forecasts/index.html>
- 510 Github page containing the Python and Azure scripts for the COVID-19 Forecast Tool  
<https://github.com/rodekruis/covid-forecast-opt-function-app>
- Introduction to Azure functions  
<https://docs.microsoft.com/en-us/azure/azure-functions/functions-overview>



- Azure Functions developer guide  
<https://docs.microsoft.com/en-us/azure/azure-functions/functions-reference>
- Azure Functions Python developer guide  
<https://docs.microsoft.com/en-us/azure/azure-functions/functions-reference-python>
- How to set up an Azure Python function app  
<https://github.com/jmargutt/azure-python-function-app>