**A Short-Term Forecast Scenario of COVID-19 Epidemic and Allocated Hospital Readiness in Egypt**

Engy Mohamed El-Ghitany

Tel. +201001781333

Fax: 002 03 4285499

Email: ingy.elghitany@gmail.com

Address: 165 El-Horreya Avenue, Alexandria, Egypt

Tropical Health Department, High Institute of Public Health, Alexandria University, Egypt

**Abstract**

**Background**

The novel virus COVID-19, also known as SARS-CoV-2, is currently rapidly spreading around the globe and pushing healthcare systems to the limits of their capacity. One of the functions of predictive models is to timely act for epidemic preparedness including hospital preparedness. In Egypt, like many other countries in the world, the epidemic situation and forecasting have not yet sufficiently studied. The study was carried out to develop a short-term forecast scenario for the COVID-19 epidemic situation in Egypt and predict the hospital needs to accommodate the growing number of cases.

**Material and Methods:** Secondary data from the COVID-2019 daily reports and the report issued 8th of April by the Egyptian Ministry of Health and Population were used. Due to the daily changing level of knowledge and data, the article reflects the status up to 18 April 2020. The prediction was based on the exponential growth rate model. For the depiction of the situation, the full length of the epidemic timeline was analyzed (from February 14th till April 18th). The growth rates and their rates of decline during the period from the 22nd of March till the 18th of April were calculated and extrapolated in the coming 7 weeks. The predicted hospital needs were assessed against the announced allocated resources.

**Results:** The epidemic curve in Egypt is on the ascending arm as of April, 18. The active cases showed exponential growth from the start of the epidemic till April, 18. At the end of this period time, the recovery rate was 23.12% and the case fatality rate (CFR) was7.39. The case fatality

rate median level during the last four weeks was 6.64. The active cases are expected to reach more than 20,000 by late May then starts to decline. The allocated regular hospital beds are predicted to show shortage by the time of the release of the paper. The intensive care units (ICU) beds and ventilators are predicted to show insufficiency on May 6.

**Conclusions:** The COVID-19 epidemic in Egypt is expected to continue on the rise for the next few weeks and expected to start to decline late in May, 2020. Our estimates should be useful in preparedness planning. Serious actions should be taken to provide ICU beds and ventilators enough for the predicted number of cases that would need them, not later than the end of April. Mitigation actions have to continue for the coming 6 weeks or until the epidemic situation is more clearly seen.

**Keywords：**

COVID-19; Egypt; prediction exponential growth rate; hospital preparedness

**Introduction**

The novel virus COVID-19, also known as SARS-CoV-2, is currently rapidly spreading around the globe and pushing healthcare systems to the limits of their capacity due to the exponential increase in the number of cases.[1, 2]

On March 11, 2020, the World Health Organization [3] [3] declared SARS-CoV-2 pandemic [3] and has defined four transmission scenarios for COVID-19: [4]

1. Countries with no cases (No Cases);

2. Countries with 1 or more cases, imported or locally detected (Sporadic Cases);

3. Countries experiencing cases clusters in time, geographic location, or common exposure (Clusters of cases);

4. Countries experiencing larger outbreaks of local transmission (Community transmission).
The virus has now spread almost worldwide and as of April, 18th, 2020, there were over 2,330,000 confirmed cases and 160,000 total deaths, globally. The information on the coronavirus is updated daily.[5]

In Egypt, since the first case of COVID-19 that was detected on February 14, 2020, the cumulative confirmations reached 2032 including 224 deaths by April 18, 2020 [6] and this number is likely to increase rapidly.

COVID-19 pandemic tests every country's readiness to confront a major health crisis. WHO has described the preparedness, readiness and response actions for COVID-19 for each transmission scenario. They included actions related to emergency response mechanisms, risk communication and public engagement, case finding, contact tracing and management, surveillance, public health measures, Infection Prevention and Control (IPC), laboratory testing, case management strategy and recommendations by case severity and risk factors and societal response.[4]

Hospital readiness is particularly of major interest. Worldwide concerns mount that the need for hospital beds will overwhelm national capacity, putting severe strains on the health care system and limiting access to necessary care.[7]

It is crucial to dynamically analyze COVID-19 available data to inform and improve decision-making as the epidemic continues to grow.[8]

Public health measures are geared to fighting the new coronavirus. Given the urgency of the COVID-19 outbreak, timely update the epidemic situation, evaluating the effectiveness of current public health interventions, and forecasting the epidemic are of great significance to all countries for epidemic control. Therefore, in this study, an exponential growth scenario was adopted for short-term forecasting of the COVID-19 epidemic situation and evaluation of the hospital readiness was analyzed based on the available secondary data.

**Methods**

The epidemic of COVID-19 in Egypt was analyzed between February 14 and April 18, 2020 by processing the publicly available secondary data reported daily through the Egyptian Ministry of Health and Population (MOHP) official channels. They included the numbers of the newly diagnosed cases, cumulative confirmed cases, seroconverted cases, cured cases, died cases, and total died cases.

The forecasting method in this study was based on the same data, but only of the four weeks before April, 18th, i.e. starting from 22nd of March, 2020.

The case fatality rate was calculated according to the standard formula of the number of dead cases/the number of total confirmed cases at a particular period time.

The number of active cases was calculated by subtraction of the removed cases from the total number of confirmed cases at a unit time. Removed cases were the total of recovered and dead

cases. A simple exponential growth model was used using Excel sheets to calculate growth rates during the 28 days. The equation used in this model was $x_t = x_0(1+r)^t$ where $x_0$ is the value of $x$ at time 0,

t is the number of time intervals that have passed,

$x_t$ is the value of $x$ after time t,

$r$ is the growth factor.

The decline of the growth rates was calculated by subtraction of the growth rate of a certain day from that of the previous day. The prediction of total and recovery cases was calculated based on the median growth rates and its median daily decline rate. The prediction of active cases was calculated by simple subtraction of the predicted removed cases from the predicted total cases.

Measures of central tendency were calculated using IBM SPSS Statistics 25.[9]

Hospital readiness data, as well as cases distribution and needs by severity, were based on the data announced by the Egyptian MOHP on April 8, 2020.[10]

**Results**

The epidemic curve (Figure 1) showed rapid exponential growth from March, 26 till April 6 then a steady rate till the 12th of April followed by a continuous daily increase in the number of new cases till the end of the study. Although the total recoveries were also increasing day by day at a faster rate than the new cases, still the total number of cases and eventually the active cases show exponential growth rates (Figure 2). As for April 18, the recovery rate was 23.12% and the CFR was7.39.

The growth rate of the active cases showed a sharp drop till the mid of March, then a steady decrease till the first few days of April when the decline slowed down but continued till reaching 16.08% on April, 18. The same pattern was shown for the recovery rate but at a shorter time interval, the slow drop started to show in the last days of March till reaching 12.95% on April, 18. Meanwhile, the growth rate of the cumulative total cases did not show striking variations although decreasing and reached 10.58% on April, 18. The case fatality linearly increased until late March and showed steady rates thereafter, while the cure rate is somewhat steady throughout the epidemic course (Figure 3). Meanwhile, an exponential increase in the active cases is depicted in Figure 4, all through the epidemic duration till April 18.

For the last four weeks, the trend lines of the log 10 growth rate of both the new and total cases showed a linear increase till the end of the study period (Figure 5). Besides, the log 10 growth rate decline of the new, total, active and recovered cases showed a linear mild decline (Figure 6). This means that still there is a mild increase in each of these rates over the last 4 weeks duration. In other words, there is an overall increase in the daily reported numbers of cases. It is worth mentioning that the least decline growth rate was that of the active cases followed by the total cases. The median of the decline of the new cases is -0.12 (Table 1). The median case fatality rate was 6.64%, while the median cure rate was 21.66%. Descriptive data of these rates including measures of dispersion are illustrated in table 1.

*A Prediction Scenario*

Based on the assumption that the median exponential growth rate decline of the last four weeks would continue, this prediction scenario was developed.

The median case fatality rate was assumed to lasts for the prediction period to calculate the removed cases (recovered+dead). Thus, the active case prediction over the coming 7 weeks is illustrated in figure 5, where the peak would be reached on May, 28 followed by a decline of the number of active cases during the first quarter of June.

Translating this forecasting on the readiness of allocated hospitals during the coming two weeks is shown in table 2. As was reported by MOHP, the allocated hospital readiness includes 2241 regular beds, 466 ICU beds and 346 ventilators. This estimation was also based on the distribution of cases in the same report as 91% of cases need regular room, 5% need ICU bed and 4% need ventilator. The forecast showed that the hospitals would have already reached their full capacity of regular rooms and they would also run out of ICU beds and ventilators on May, 6th.

**Discussion**

It is always challenging to predict the course of a pandemic caused by a novel infectious agent. As learnt from the earlier pandemics, several waves of the disease might occur over time. The deadliest Spanish influenza, which killed over 50 million people between 1918 and 1920, had initially mild course with high infectivity. However, the second wave of the flu was characterized by extremely high mortality.[11]

The epidemic curve in Egypt as till April, 18 seems to be still in its ascending arm and the cumulative active cases show exponential growth.

The distribution of  active cases all over the world is quite similar to the active cases growth rate in Egypt.[12] This number is dependent on the natural history of the virus as well as the total number of cases.

Egypt, likewise the rest of the world, has new cases and new recoveries curve that looks identical with a gap in favor of the new cases.[12] It is believed that the kinetic parameter that describes the recovery rate seems to be similar, irrespective of the country.[13] The global rate on April 18 was 25.59% which is close to that of Egypt (23.12).

Although it is still too early to make a conclusive statement of COVID-19 CFR or mortality rate, it tempted many researchers to investigate.[14] There is a wide variation in the reported CFR so far. Most probably due to the denominator, a major determinant of the CFR. This difference originates from the variation in the policy of testing between countries and sometimes within one country.  Underreporting would have the effect of decreasing the denominator and inflating the CFR above its real value.[12]. Another factor is whether the calculation was made from opened or closed cases. Generally speaking, the initial estimate of global COVID-19 CFR was 2% on January 29[15] and 3.4% as of March 3.(Organization, 2020 #61)

Real-time epidemic forecasting is a crucial tool for epidemic preparedness and response actions.[16] The adopted exponential growth rate model in this study is rationalized by the early growth of many infectious diseases epidemics, such as influenza, which is usually well approximated by exponential growth.[17] Many co-factors in this context would influence the prediction model. These factors might include, but not limited to, transmission rate, size of susceptibles, behavior changes, extend and success of the mitigation efforts, screening policy, the number of diagnosed cases relative to the real number and intrinsic features of the disease such as the length of the incubation period, time from disease to outcome and the level of clustering. [18]

As the results of the current study showed that, Egypt would be run out of allocated regular hospital rooms by the time of the study release, there has already been an action towards that. It was announced on the same date, April,18 that the Egyptian government has spent 25 million

pounds to prepare youth centers and students hostels to accommodate non-critical COVID-19 cases.[19]

The current results should raise the alert status regarding the hospital preparedness. Proactive steps have to be urgently and promptly taken to provide ICU beds and ventilators for COVID-19 critical cases by the end of April before the predicted date of May 6.

The active cases are predicted to reach more than 20,000 by late May before starting to decline. This would also be taken with caution as it was assumed that the reported new cases worldwide constitute only 6% of real cases. The real number could be between 29 and 83 times as high as the official tallies. This means that public health decision-makers need to practice extreme caution when interpreting case numbers for planning purposes and great improvements in the preparedness of countries to deal with the epidemic.[20]

## Conclusion

The COVID-19 epidemic curve is still rising in Egypt and it is expected to duplicate the active cases number many times till late May when the number starts to decrease. The growth rates show increase and predicted to continue their rise over the coming six weeks. As was prepared for the regular hospital beds, serious actions should be taken to provide ICU beds and ventilators enough for the predicted number not later than the end of April. Mitigation actions have to continue for the coming 6 weeks or until the epidemic situation is more clearly seen.

## Limitations

This study used only secondary publicly available data due to a lack of data accessibility. Therefore, some important co-factors were not put into consideration. One of them is the duration of illness till the outcome in different cases severity which greatly influences the hospital occupancy. These data would make the occupancy of hospital beds even worse. Other hospital preparedness items were not studied, for the same reason, such as the number of health care workers, their training and expertise and data related to the use and availability of personal protective equipment.

Further studies are needed for quantifying the contribution of each of these factors that could help refine estimates of final epidemic size and the relative impact of different mitigation efforts in current and future epidemics.

**Conflict of interest**

None to declare

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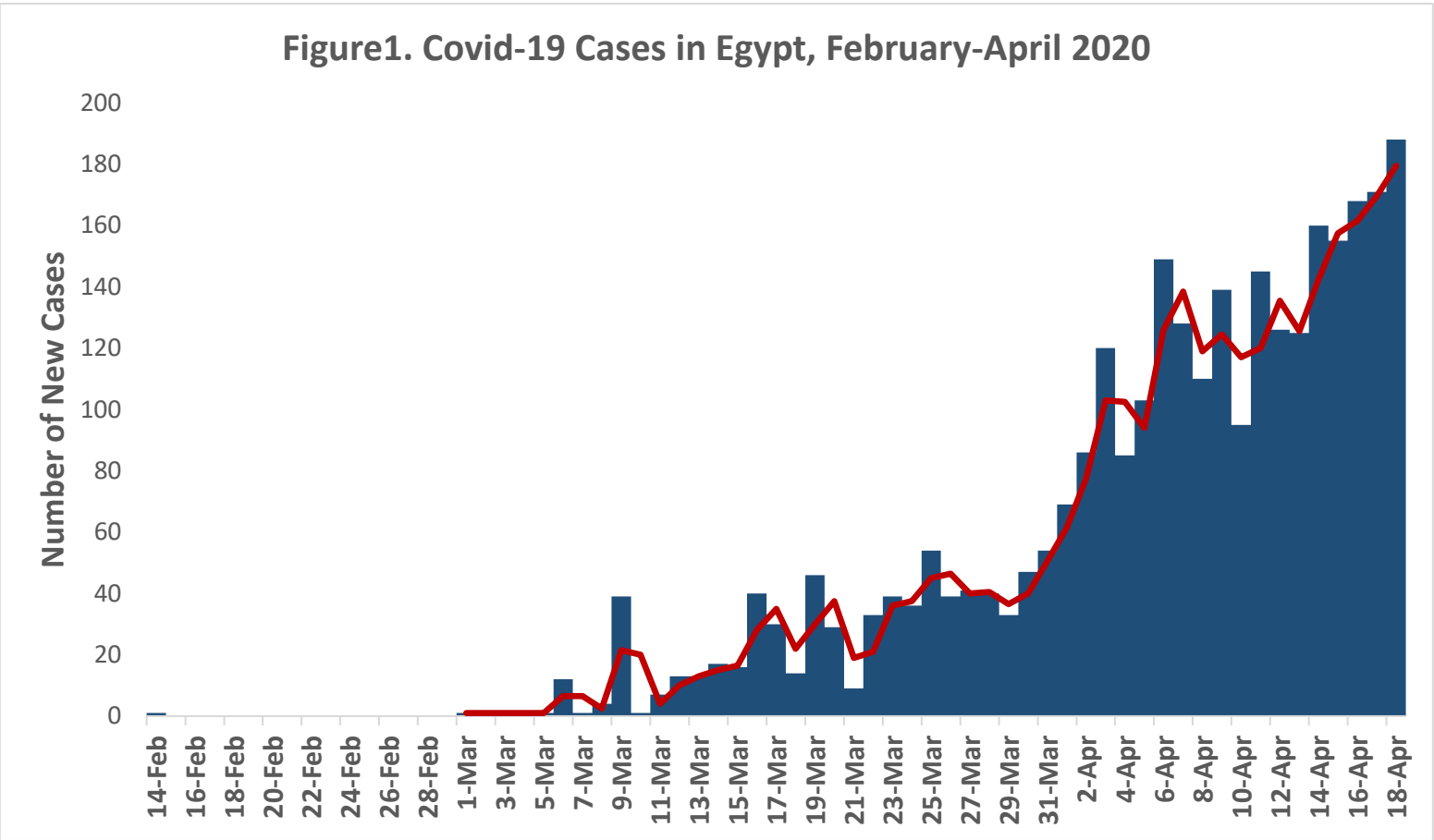Figure1. Covid-19 Cases in Egypt, February-April 2020

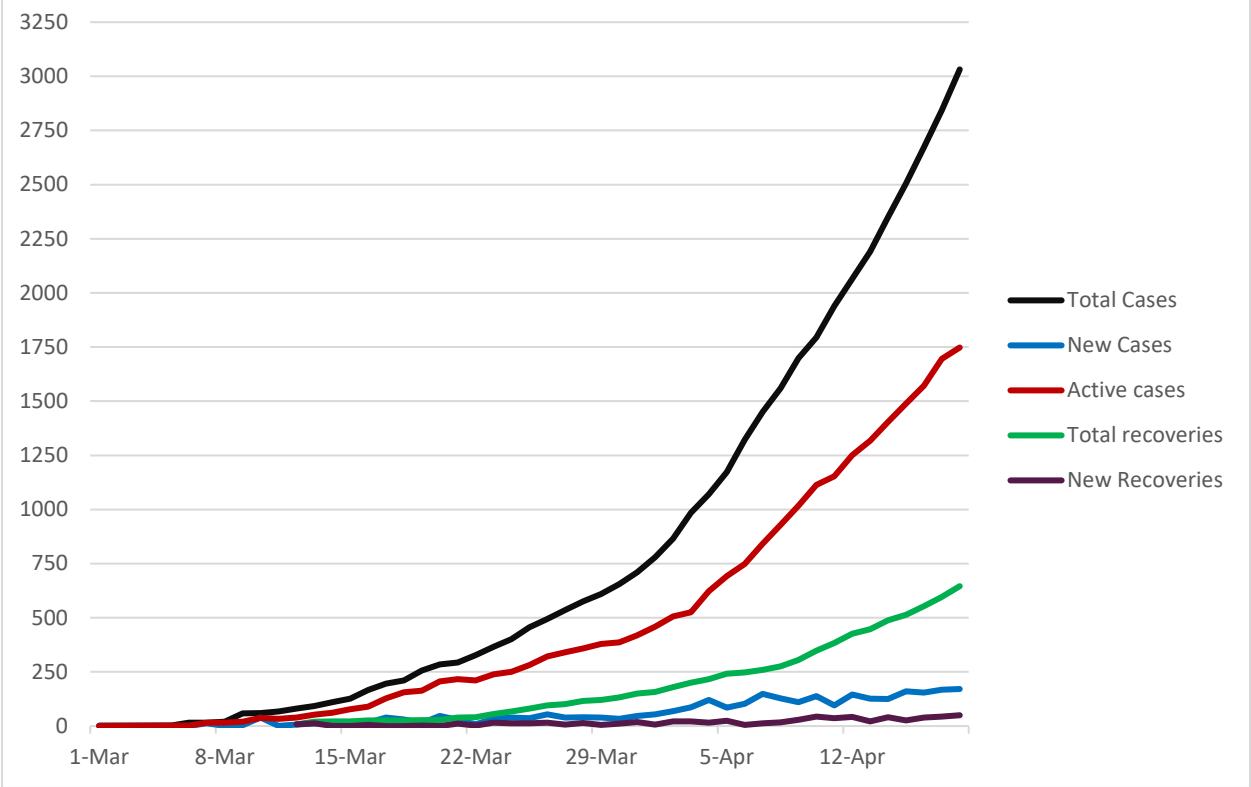Figure 2. Categorization of the COVID-19 cases from the start of the epidemic till April 18, 2020
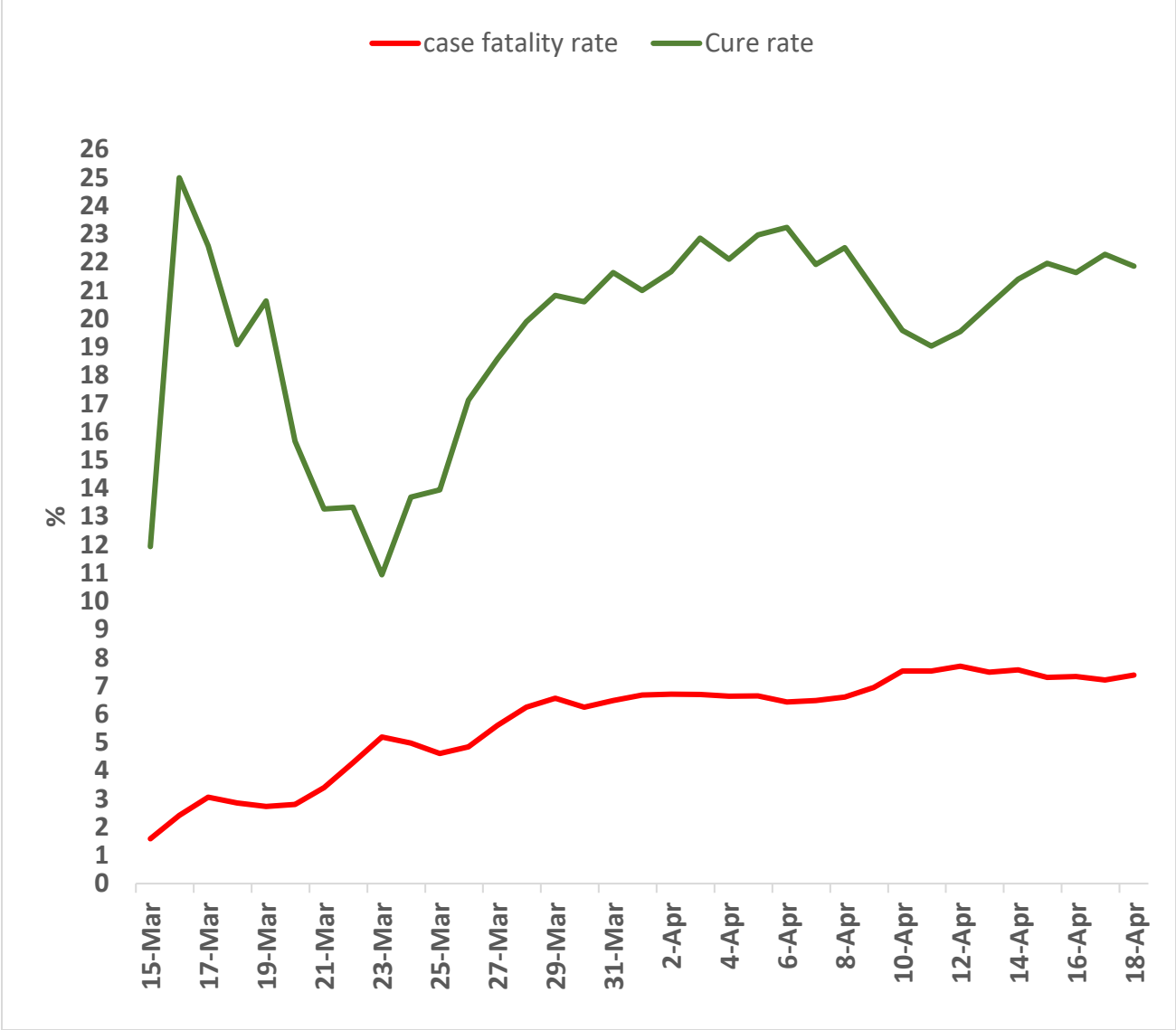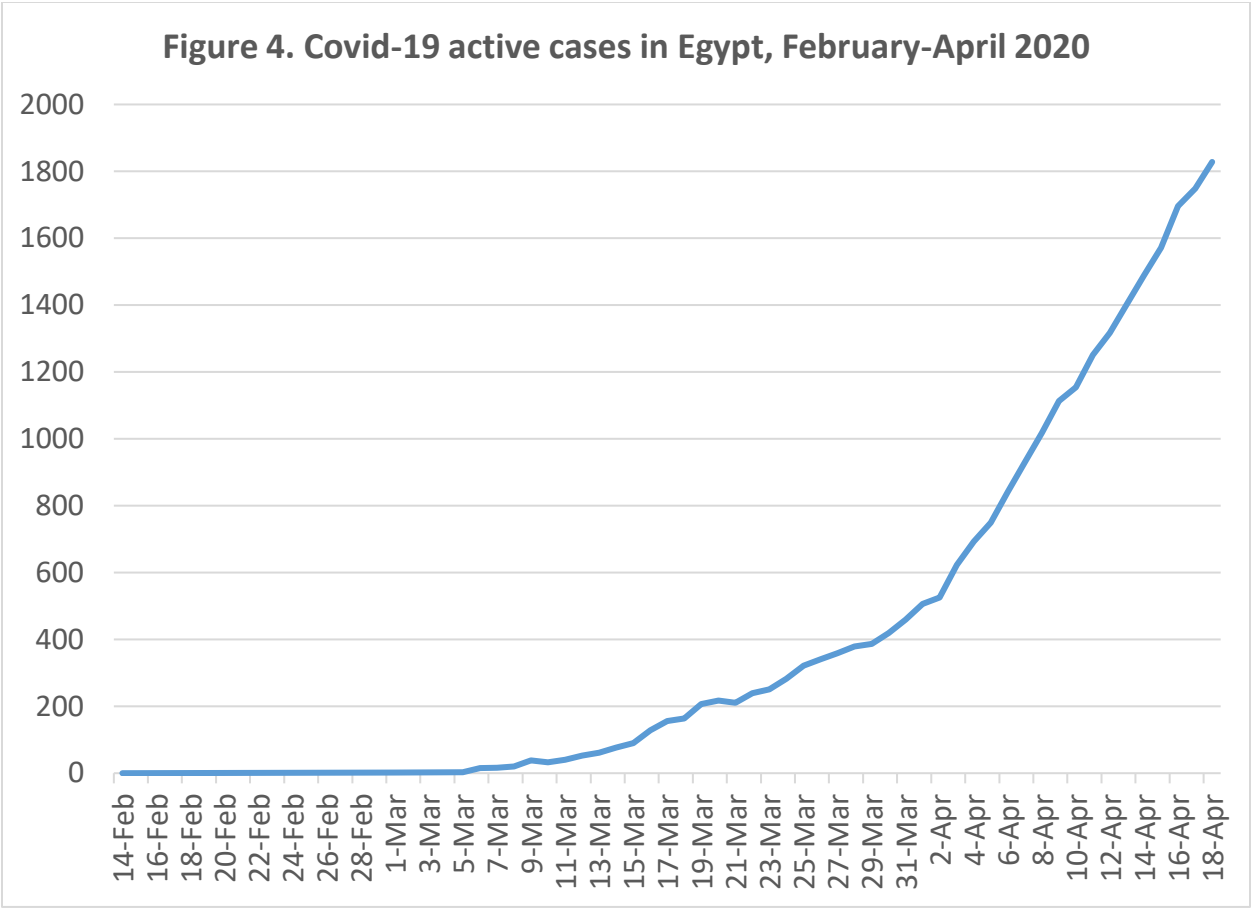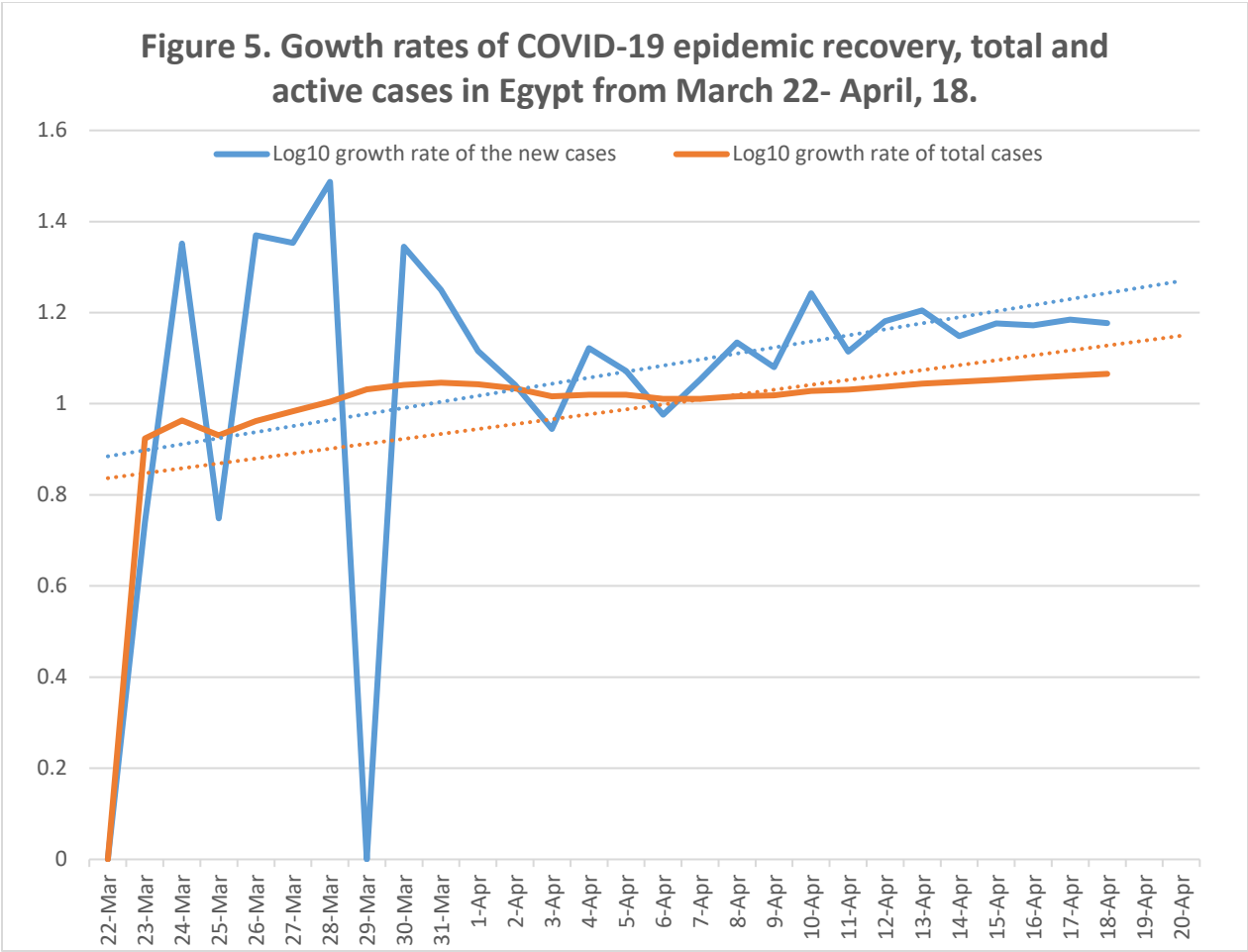
Figure 3. Covid-19 cure rate and case fatality rate in Egypt

Figure 4. Covid-19 active cases in Egypt, February-April 2020

Figure 5. Gowth rates of COVID-19 epidemic recovery, total and active cases in Egypt from March 22- April, 18.

Figure 6. The decline of the total COVID-19 new, active and removed cases growth rates in Egypt from 22nd March till 18th April 2020.
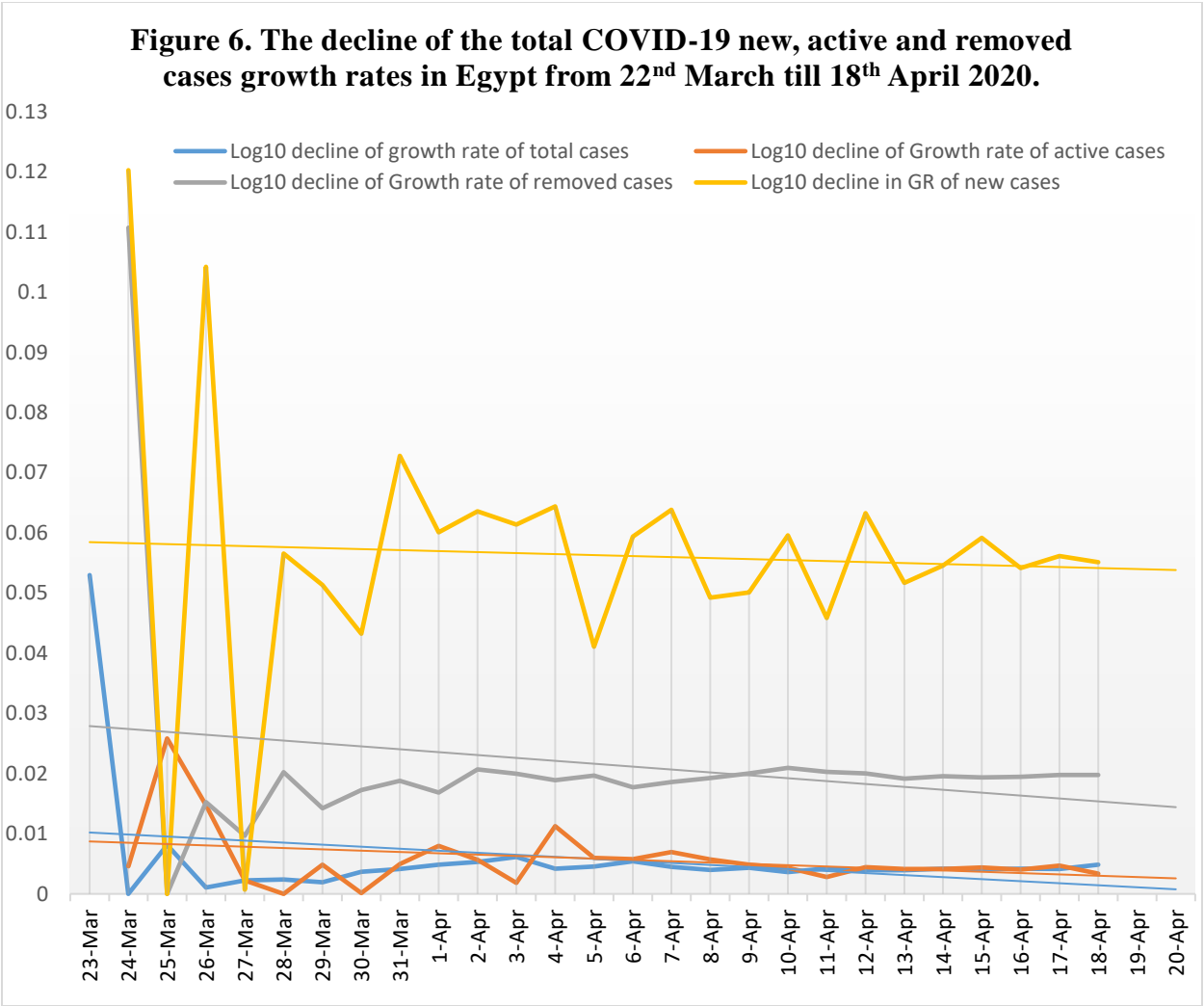
**Figure 7. Short-term Predicted active cases of COVID-19 in Egypt applying the median growth rate of the previous four weeks.**
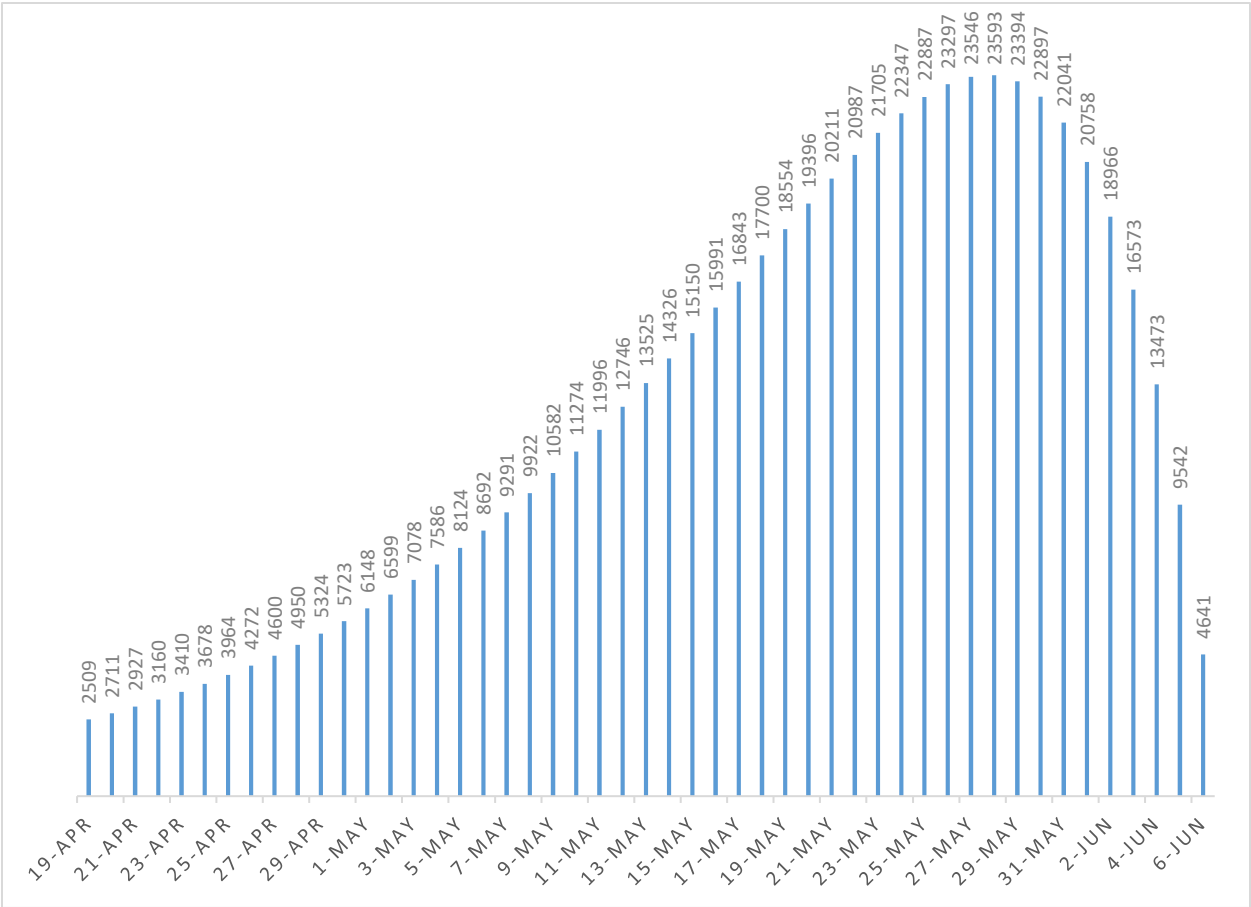
**Table 1. COVID-19 growth, case fatality and cure rates in Egypt from 22nd of March till 18th of April, 2020.**

| Rate | Minimum % | Maximum % | Median % | Mean % | Std. Deviation % |
|---|---|---|---|---|---|
| **Growth rate of the** | | | | | |
| New cases | 0.00 | 18.18 | 6.72 | 7.47 | 3.80 |
| Total cases | 8.60 | 11.92 | 9.37 | 9.61 | 0.86 |
| Active cases | 0.00 | 8.33 | 7.20 | 6.66 | 1.71 |
| Removed cases | 10.03 | 24.29 | 11.59 | 12.90 | 3.35 |
| **Decline in the growth rate of the** | | | | | |
| New cases | -18.18 | 13.74 | -0.12 | -0.25 | 6.09 |
| Total cases | -11.92 | 1.1 | 0.09 | -0.32 | 2.35 |
| Active cases | -5.06 | 1.06 | 0.00 | -0.26 | 1.18 |
| Removed cases | -24.29 | 4.76 | 0.17 | -0.37 | 4.88 |
| **Case Fatality Rate** | 4.28 | 7.70 | 6.64 | 6.50 | 0.96 |
| **Cure Rate** | 17.13 | 23.24 | 21.66 | 21.29 | 1.49 |

**Table 2. Short-term forecast of the needed number of regular hospital room beds, ICU beds and ventilators till May 1st.**

| Date | Needed regular room No. | Needed ICU bed No. | Needed ventilator No. |
|---|---|---|---|
| 19-Apr | 2283 | 125 | 100 |
| 20-Apr | 2467 | 136 | 108 |
| 21-Apr | 2664 | 146 | 117 |
| 22-Apr | 2876 | 158 | 126 |
| 23-Apr | 3103 | 171 | 136 |
| 24-Apr | 3347 | 184 | 147 |
| 25-Apr | 3607 | 198 | 159 |
| 26-Apr | 3888 | 214 | 171 |
| 27-Apr | 4186 | 230 | 184 |
| 28-Apr | 4505 | 248 | 198 |
| 29-Apr | 4845 | 266 | 213 |
| 30-Apr | 5208 | 286 | 229 |
| 1-May | 5595 | 307 | 246 |
| 2-May | 6005 | 330 | 264 |
| 3-May | 6441 | 354 | 283 |
| 4-May | 6903 | 379 | 303 |
| 5-May | 7393 | 406 | 325 |
| 6-May | 7910 | 435 | 348 |
| 7-May | 8455 | 465 | 372 |
| 8-May | 9029 | 496 | 397 |

The highlighted cells represent when the needs exceed the allocated resources as per the Egyptian MOHP report on April, 8