Flattening COVID-19 Curve in Egypt: An Epidemiological Modelling

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Abstract

Background: Flattening the curve refers to community isolation measures that keep the daily number of disease cases at a manageable level for medical providers. Efforts to completely contain the COVID – 19 have failed. As there is currently no vaccine or specific medication to treat COVID-19, the only way to flatten the curve is through collective action of mitigation efforts.

Objectives: The study was carried out with aim to study the effect of mitigation efforts in reducing the overall COVID -19 attack rate and flattening the curve of COVID-19 in Egypt. **Methods:** Secondary data in the situation reports of WHO, Worldometer and Egyptian MoHP Report about the COVID-19 epidemic in Egypt were analyzed till June 27, 2020. Survival analysis was carried out to determine the cumulative proportional survival of COVID-19. The Susceptible Infected Recovered (SIR) model was used to study the epidemic dynamics of COVID-19 pandemic.

Results: In Egypt in the fourth week after exposure β was 0.17 and $\gamma = 0.07$. The fraction of infectious individuals will grow exponentially as the exponential growth rate was 0.10, with an epidemic time of 7 days. R in 22 [nd] June was 0.80 (less than one person infected) where $\beta=0.21$ and $\gamma =0.26$. There was reduction in the actual overall attack rate at 22nd June of 96 % of its value without intervention with a cumulative proportional survival of 0.89. There was flattening of the curve.

Conclusion and recommendation: Mitigation efforts of Egypt had succeeded in flattening the curve of COVID-19 Pandemic. Even though, strengthening all the mitigation efforts to keep the exposure probability, as well as the transmission rate as low as possible is mandatory for containment of the epidemic.

Keywords: COVID-19, Egypt, Epidemic SIR Model, Pandemic, Flattening the curve

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Introduction

The Coronavirus pandemic is the defining global health crisis of our time. Since its emergence in late 2019, the virus has spread to every continent. Countries are racing to slow the spread of the disease... Efforts to completely contain the COVID – 19 the pandemic responsible for infecting more than five and half millions with the disease, have failed. In less than three months, the global number of confirmed COVID-19 cases increases more than seventy times . That infection rate, scary as it sounds, hides just how much the out of control virus has spread, especially in the hardest-hit. [1, 2]

Flattening the curve refers to community isolation measures that keep the daily number of disease cases at a manageable level for medical providers In epidemiology, the idea of slowing a virus' spread so that fewer people need to seek treatment at any given time is known as "flattening the curve A flatter curve assumes the same number of people ultimately get infected, but over a longer period of time. A slower infection rate means a less stressed health care system, fewer hospital visits on any given day and fewer sick people being turned away. [3, 4]

As there is currently no vaccine or specific medication to treat COVID-19, and because testing is so limited in many countries, the only way to flatten the curve is through collective action of mitigation efforts together with epidemiologic surveillance , contact tracing and epidemiological testing where the contacts of infected people are identified, tested in turn and isolated as needed. [5]

The study was carried out with aim to study the effect of mitigation efforts in reducing the overall COVID -19 attack rate and the consequential excess mortality attributed to the pandemic, delay and reduce the peak attack rate together with flattening the curve of COVID-19 pandemic in Egypt.

Methods

The data was collected essentially by using secondary data. All cases and deaths in the situation reports of WHO [6] and the Worldometer till May 28th, 2020 were included in the study. [7] The data were entered, analyzed by IBM SPSS Statistics, 25th edition [9]. Survival analysis was carried out to determine the cumulative proportional survival of COVID-19. Wolfram Player 12 software was used for the Susceptible Infected Recovered (SIR) epidemic dynamics of COVID-19, logistic growth model and reducing fatalities from COVID-19 pandemic. [10]

The following SIR model was considered: where S is the fraction of susceptible individuals, I is the fraction of infectious individuals, and R is the fraction of recovered individuals, β is the transmission rate per infectious individual, and γ is the recovery rate. So in the SIR model, members of a population are categorized into one of three groups: those who are susceptible to being infected, those who have been infected and are able to spread the disease to susceptible individuals, and those who have recovered from the disease. Movement of individuals is one-way only, S - I – R.

Results

In Egypt In the fourth week after exposure (3rd to 9th March 2020) the number of reported cases was 55 and the recovered 4. The recovery rate was calculated by dividing the recovered cases by the reported cases, 4/55 = 0.07. β was calculated by the equation:

$C = \beta SI - I\gamma$

$100 = \beta \times 102332404 \times 55 - 55 \times 0.07$

$\beta = 0.17$

Where C is the incidence of cases in the second week, S is the susceptible population, I is the number of cases in fourth week after exposure and γ is the recovery rate

Note that the basic reproduction number is $R = \beta/\gamma$ the basic reproductive rate $(R) = 2.4$ (about two and half person infected). If transmission rate – recovery rate < 0, the fraction of infectious individuals will not grows exponentially and the incidence rate (number of new cases per unit time) also will not increase exponentially. In Egypt in fourth week after exposure β was 0.17 and $\gamma = 0.07$. The fraction of infectious individuals will grow exponentially and the exponential growth rate will be $\lambda = \beta - \gamma$. i.e. 0.17- 0.07=0.10, during the early phase of COVID-19 Pandemic the epidemic time was about 7 days $(\ln 2/\lambda)$

Calculating R by 22nd June, it was 0.80 (less than one person infected) where $\beta = 0.21$ and $\gamma = 0.26$

. Figure (1) shows the distribution of the cases up to June 27 ,2020 .For calculating the case fatality rate, survival analysis was used where new cases were added, deaths and recovered were subtracted. The cumulative proportional survival of COVID-19 was 0.89. This means that 89% of the active cases of COVID -19 at 22nd June in Egypt will survive by end of the epidemic, Table (1).

Figure (1) Distribution of COVID-19 cases in Egypt
(Feb. 8 –June 27, 2020)
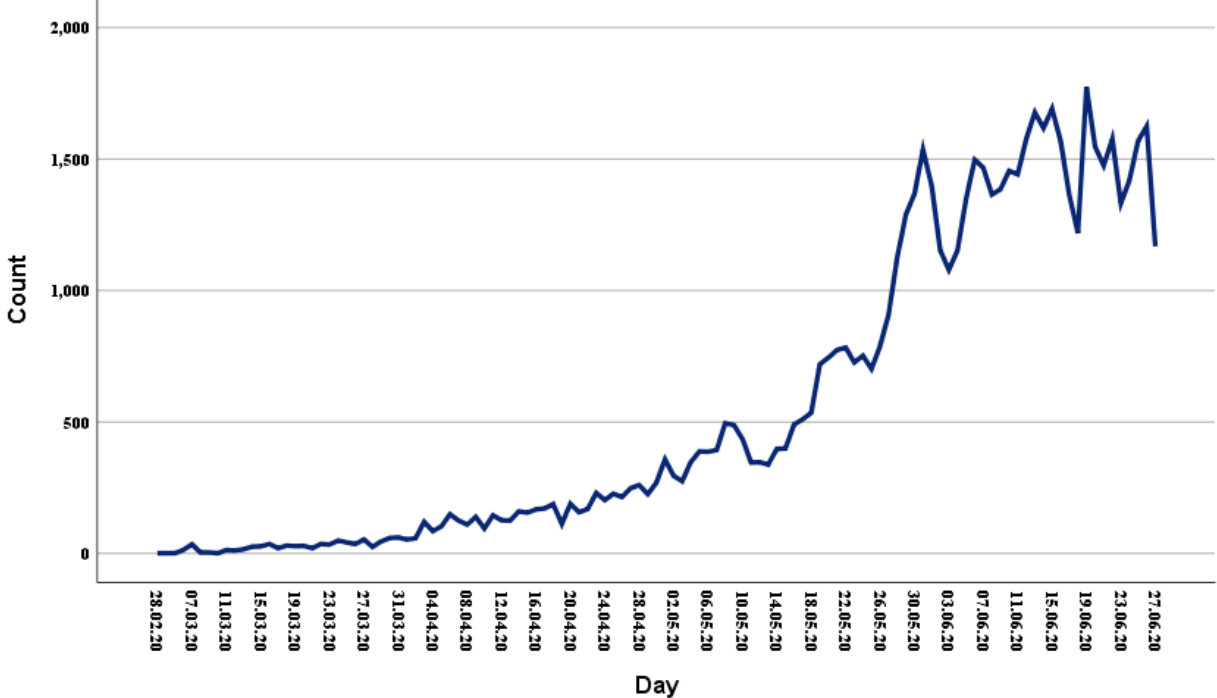
Table (1) Life table of proportion surviving of COVID-19 cases in Egypt (10th February - 22nd June 2020)

Interval Start Time	Number Entering Interval	Number of Terminal Events	Proportion Terminating	Proportion Surviving
0	40131	0	.00	1.00
1	40131	2340	.11	0.89

The actual overall attack rate up to 22nd June was 55 per 100,000 and the projected rate without intervention was 1600. This difference is significant (c OR = 29.554 (22.547- 38.6665), P =0.0000) with 96% reduction of its value without intervention. As for deaths, it was projected based on a cumulative proportional survival of COVID -19 cases of 0.81. [11] .Figure (2) shows how the epidemic curve was flattened in Egypt. The same picture was observed for deaths (Figure 3)

The total tests carried out in Egypt up to 27 Th June was 135000 with about1322 tests per million. Based on β of 0.50 and γ of 0.26 of the projected cases at 22nd of June, figure (4) shows the reduced fatalities from COVID-19 Pandemic in Egypt at 22nd June 2020. Figure (5A, B&C) shows the SIR Epidemic Dynamics of COVID-19 in the early stage of the epidemic and that of the projected and actual cases at 22 nd June.
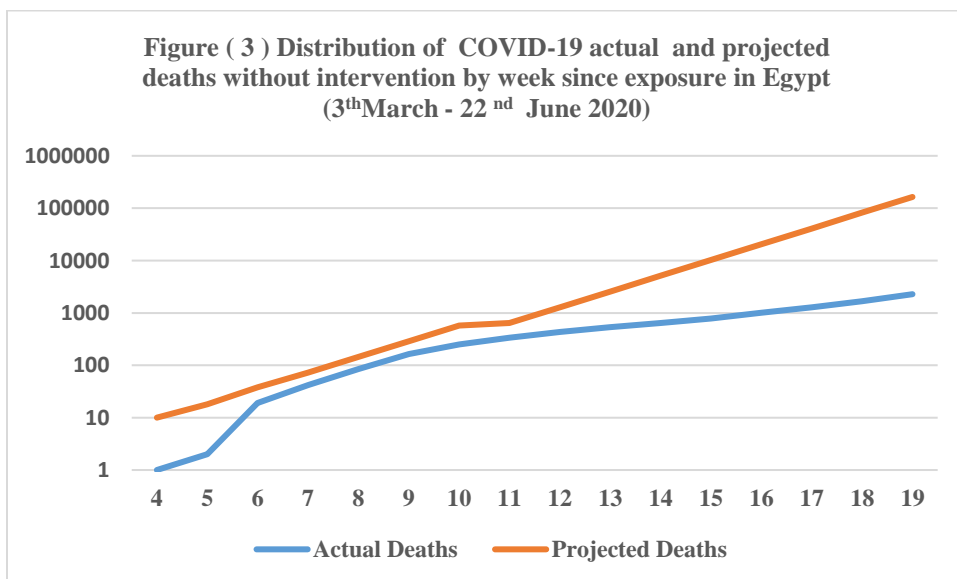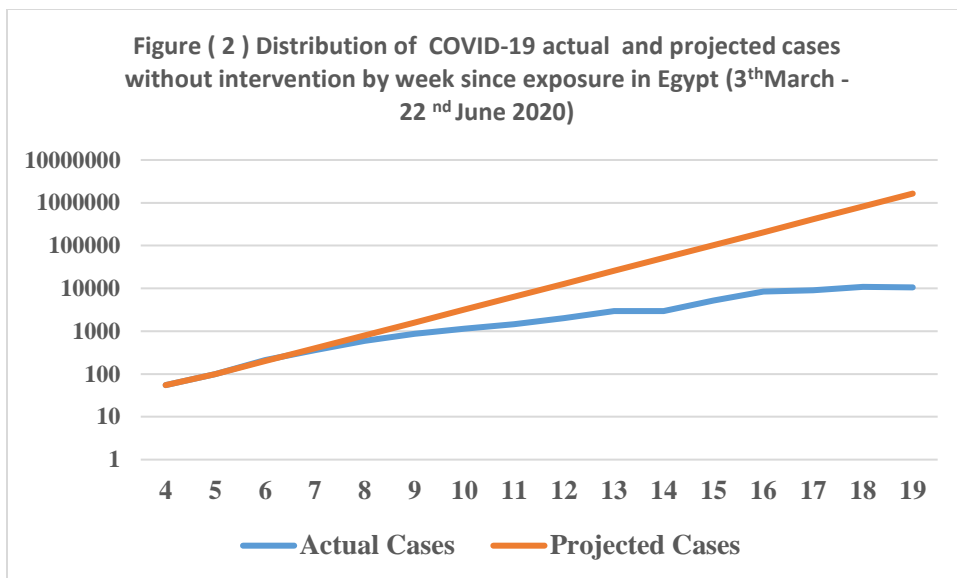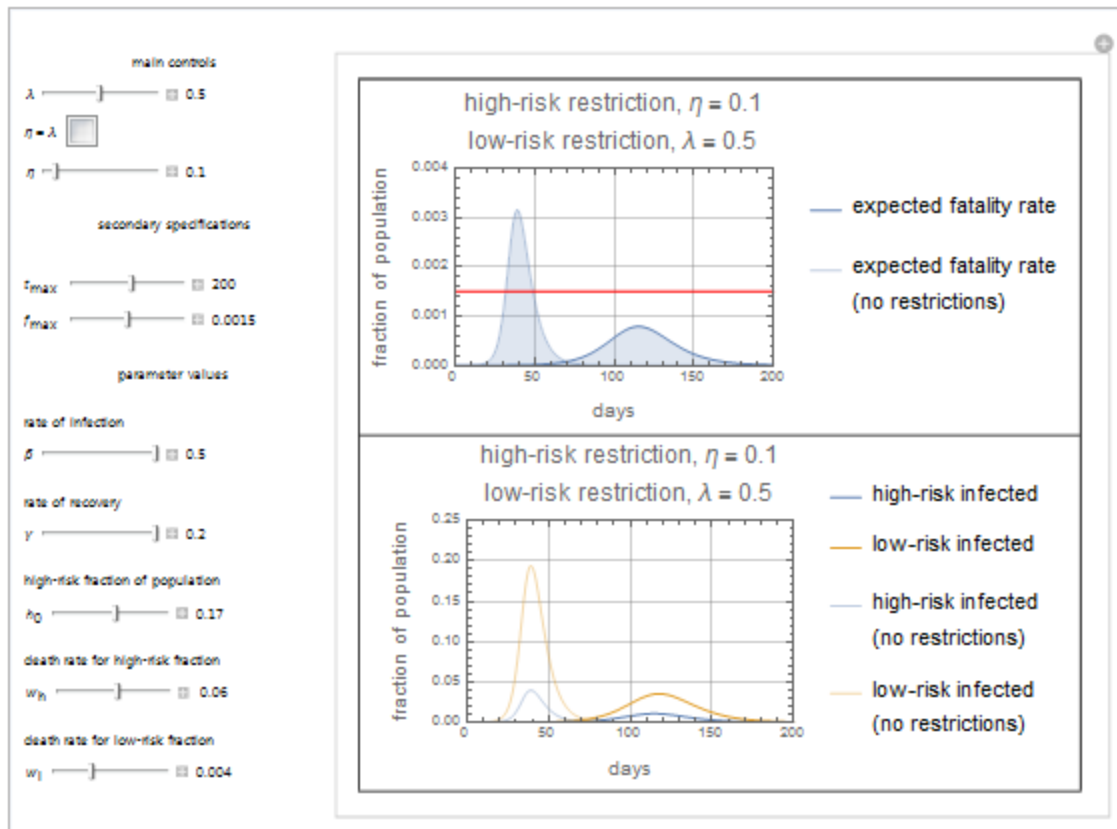
Figure (4) Reducing fatalities from COVID-19 Pandemic in Egypt at 22 [nd] June 2020
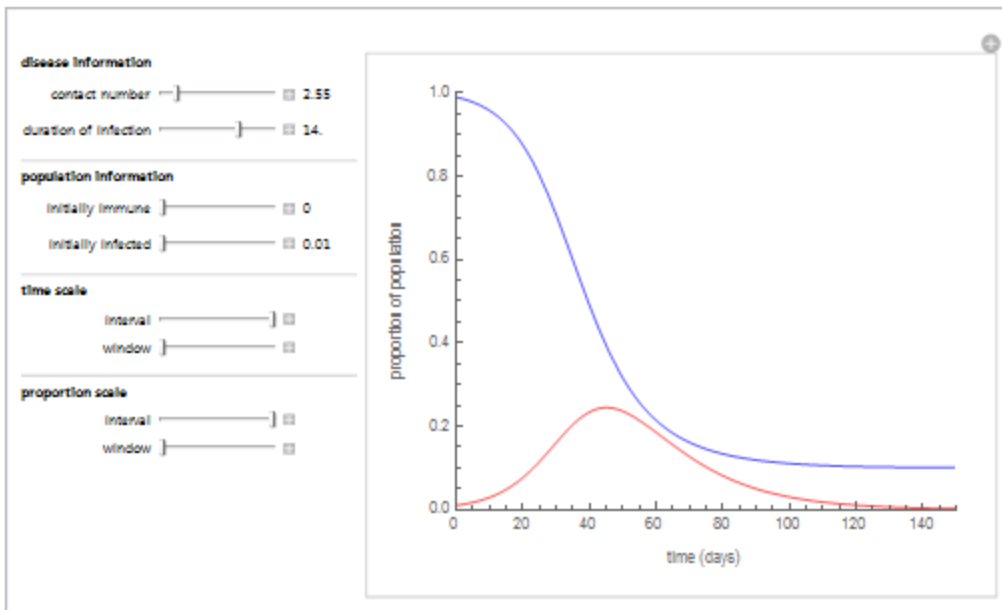
Figure (5A) SIR Epidemic Dynamics of COVID-19 at 3rd March 2020
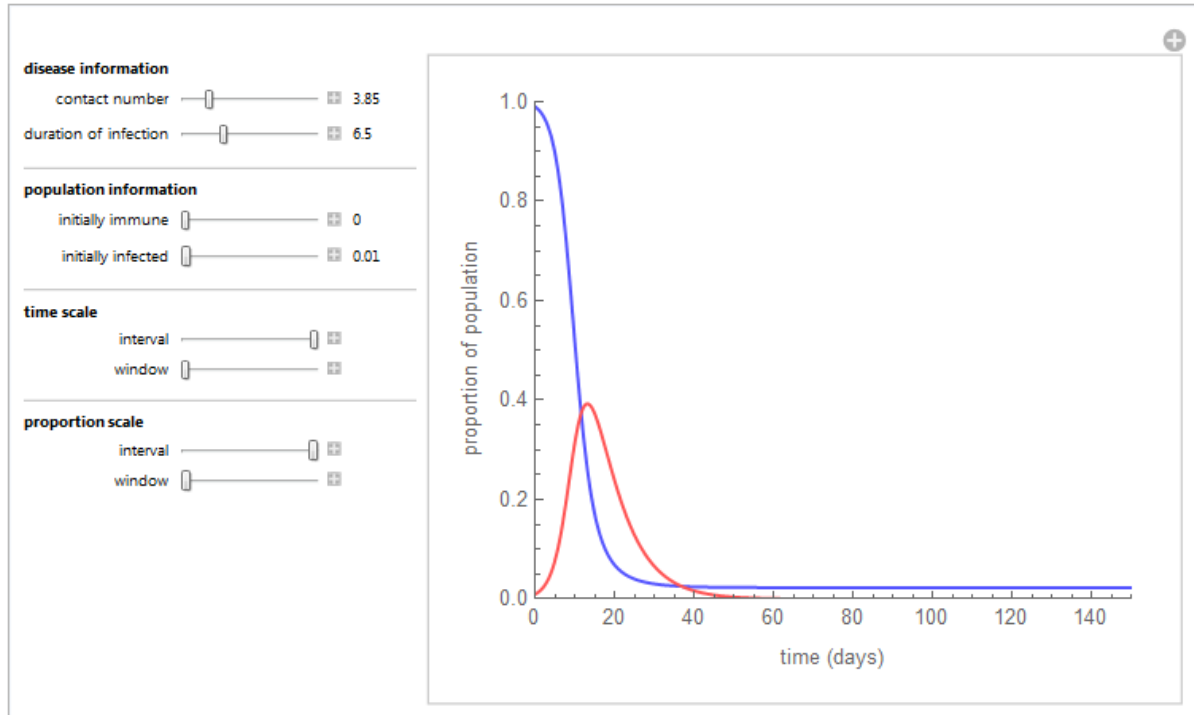
Figure (5B) SIR Epidemic Dynamics of Projected COVID-19 in Egypt at 22nd June 2020 without intervention
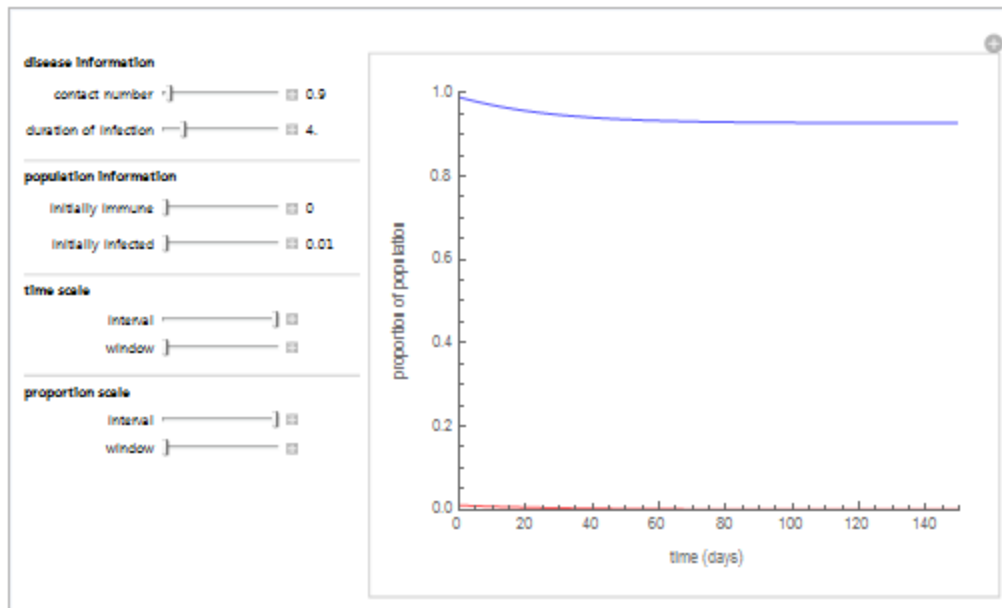
Figure (5C) SIR Epidemic Dynamics of Actual COVID-19 in Egypt at 22nd June 2020

Applying a Logistic Growth Model for COVID-19, the pandemic in Egypt may be ended by end of August 2020 bases on 63923 cumulative cases and a growth rate of 0.1 at 27th June 2020, Figure (6).

Figure (6) Logistic Growth Model for COVID-19 in Egypt

Discussion

The situation of COVID-19 pandemic in Egypt as compared to other parts of the world is promising. Mitigation efforts of Egypt had succeeded in delaying the peak of the curve after the seventh week of first exposure. The transmission rate is smaller than the recovery rate with no exponential growth. Egypt is one of the countries, alongside China [11], to flatten the curve of new infections of COVID-19 pandemic. Egypt has done so without huge outbreaks, without China's draconian restrictions on speech and movement, or economically damaging lockdowns like those in Europe and the United States. [11]

Much rather be ahead of the curve than behind it. To explain, Egypt did not underestimate the problem since the first reported case in Egypt on 8th February, knowing well that COVID-19 is inevitable and started to deal early, to limit transmission and increase recovery. Our results suggest a critical role of social distancing in the potential control of COVID-19 pandemic and indicate that such interventions are capable of arresting COVID-19 epidemic development, but only if they are used in combination, activated without delay and maintained for a relatively long period. Limiting transmission in Egypt was difficult without the mitigation procedures of the government as the household and social contact is high (three contacts, as the household number is 4 in Egypt). [12, 13] WHO COVID-19 technical mission in Egypt on March, 5 concluded that considerable efforts have been made by the government in allocating additional dedicated human and financial resources needed to contain the outbreak... [14] The mission also added that Egypt's strong disease surveillance system and contact tracing efforts have proven effective in controlling and managing sporadic and clusters of cases before they can spread. Epidemiological testing — where the contacts of infected people are identified, tested in turn and isolated as needed — is the only way to fully break the chains of transmission, says. Without it, the virus will come roaring back as soon as social distancing guidelines are relaxed. Recent border closures now provide an opportunity to enhance screening and rapid testing capacity using a risk assessment approach. However it is important to note the sensitivity of RT-PCR testing, is less than optimal. The area under the cure of RT-PCR is about 75% with a fair discrimination power. [15] A single negative RT-PCR should not exclude

COVID-19, especially if clinical suspicion is high. The combination of clinical symptoms, exposure history, typical CT imaging features, and dynamic changes must be considered to identify COVID-19 with higher sensitivity. This explains the non-significant   correlation of case fatality rate observed in this study by the tests carried out.

Besides, significant efforts have been made to ensure the public is updated on the current situation, including working with other sectors to reach vulnerable populations. Greater coordination and partnerships with civil society, non-governmental organizations (NGOs), and the media that ensure that the public can make informed decisions, without succumbing to mistrust and the stigma associated with the disease. [16, 17] However, as epidemiologists, we need to be very cautious with our optimism taking into account those who are COVID-19 positive, but have not been tested and the number of people with either mild illness or who are non-symptomatic.

Conclusion and recommendation: Mitigation efforts of Egypt had succeeded in flattening the curve of COVID-19 Pandemic. Even though, strengthening all the mitigation efforts to keep the exposure probability, as well as the transmission rate as low as possible is mandatory for containment of the epidemic. More studies is needed to evaluate the validity of the RT-PCR as a predictor of COVID-19 is needed.

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