Predictive Modelling of COVID-19 Pandemic

Emmanuel Agunloye and Mohammed A. Usman
Department of Chemical and Petroleum Engineering, University of Lagos

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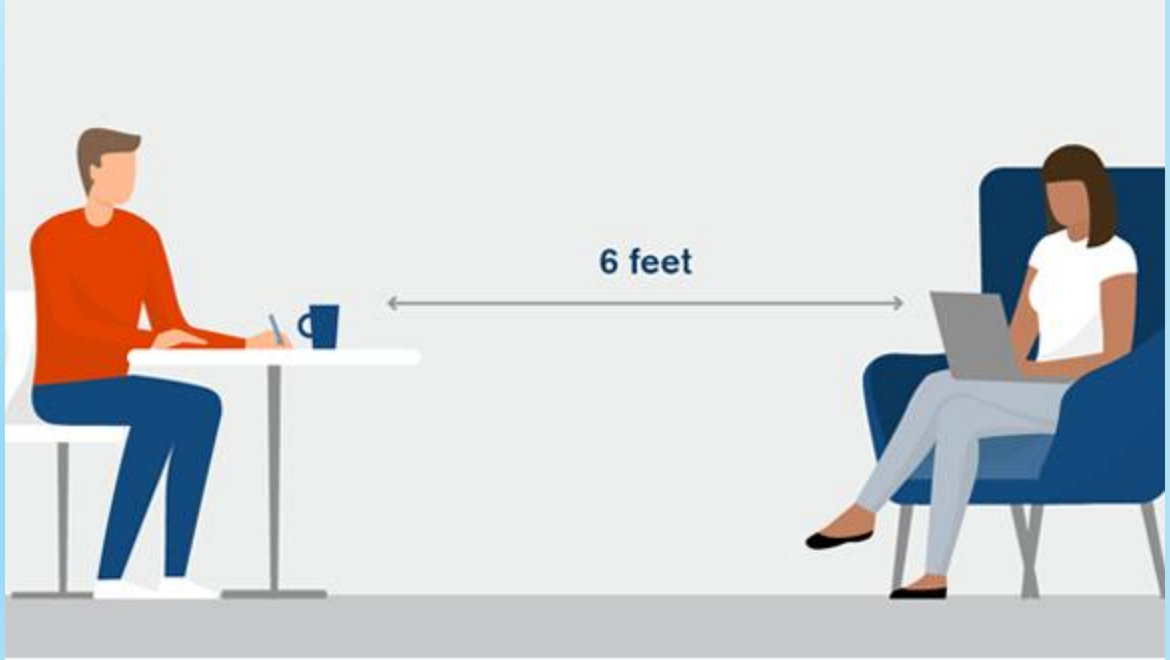
Presentation outline

- Introduction to COVID-19 modelling and research objective
- Modelling approach and model development
- Model validation
- Conclusions

Introduction _ COVID-19 world

- COVID-19 is a global pandemic that has changed our lifestyles: face mask, social distancing and travel restrictions.



Introduction _ COVID-19 figures and modelling motivation

- The disease began in late COVID-19 in Wuhan China by zoonosis with a couple of confirmed cases.
- Current statistics shows more than 168 million people worldwide confirmed with the disease, about a million deaths.
- In Nigeria, new daily cases are decreasing but more than 166,000 confirmed cases and more than a thousand death.

May 24, 2021		
	Nigeria	World
Confirmed	166,061	168,022,914
Discharged	156,492	149,366,520
Deaths	2,067	3,488,512
Active	7,502	15,167,882
New	42	369,321

COVID-19 modelling – motivation and objectives

- With the exponential spread of the disease, we were worried about various measures imposed on the society.
- Modelling can be used as a tool to monitor the trend and the impact of the measures.
- As the disease spreads by interactions between carriers and the rest of the population, we employ a balance equation modelling assuming a closed society.

Objective:

to monitor and predict the impact of health protocols on the time evolution of total confirmed cases of COVID-19.

Modelling approach – balance equation modelling

$$Acc = (In - Out) + Gen \quad (1)$$

$$\frac{dP_i(t)}{dt} = r_i(t) \quad (2)$$

$$\frac{dP_F}{dt} = k_F P_F P_S - (k_R + k_D) P_F = k_F P_F P_S \quad (3)$$

$$\ln\left(P_F / P_{F_0}\right) = k_F B t; P_F = P_{F_0} e^{(At)} \quad (4)$$

- A determines the spreading rate of COVID-19,
- Its maximum value would correspond to a congested population and the early stage of the pandemic

Key model assumptions:

1. A closed society
2. Considering the early part of the pandemic, thus ignoring recovery and death terms.
3. Constant susceptible population.

P_F: infected population
P_F: susceptible population
P_F: recovered population
P_F: dead population

Modelling – social distancing effect

- As social distancing and other measures are introduced, its value begins to decrease.

1. Worst case (A_C) – highest value would occur in a congested area such as in a BRT bus:

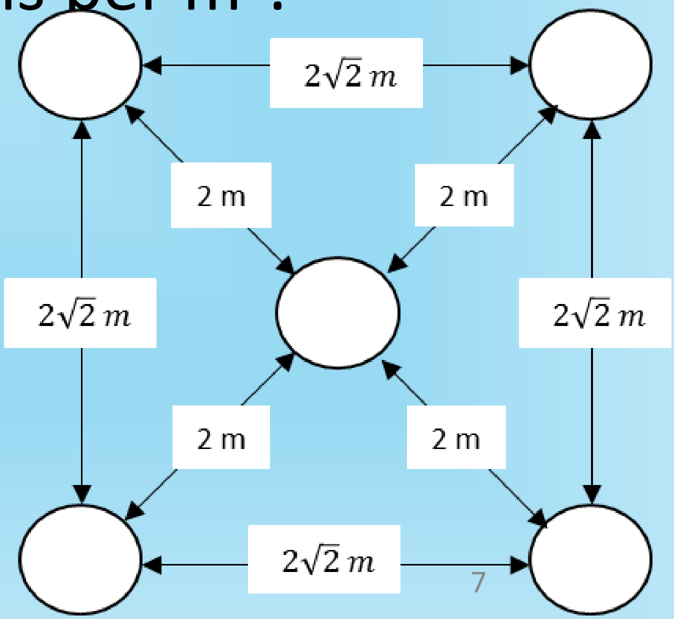
6 by 6 people occupying 2 by 2 m^2, that is, 9 persons per m^2.

2. Minimum social distance (A_S):

5 persons per 8 m^2, that is, 0.625 person per m^2

when compared

$$A_S = 0.07A_C$$



Modelling – social distancing effect

3. Total lockdown (A_L) – Under an absolute total lockdown situation in Nigeria, where the value of B_S is 0.000218 person per m^2 as shown is Section 2, Eq. (26) becomes:

$$A_L = k_F B_S = 2.42 \times 10^{-5} A_C \qquad (5)$$

Thus, the disease spread under a total lockdown is negligible in comparison to the spread in a congested situation.

Modelling results

- COVID-19 data from China in January 2020 were used for parameter estimation and model validation.
- The parameter to be estimated is the exponential constant, A.
- Some of the data were used to estimate A while the remaining data were used for the model validation.

Modelling results – Parameter estimation

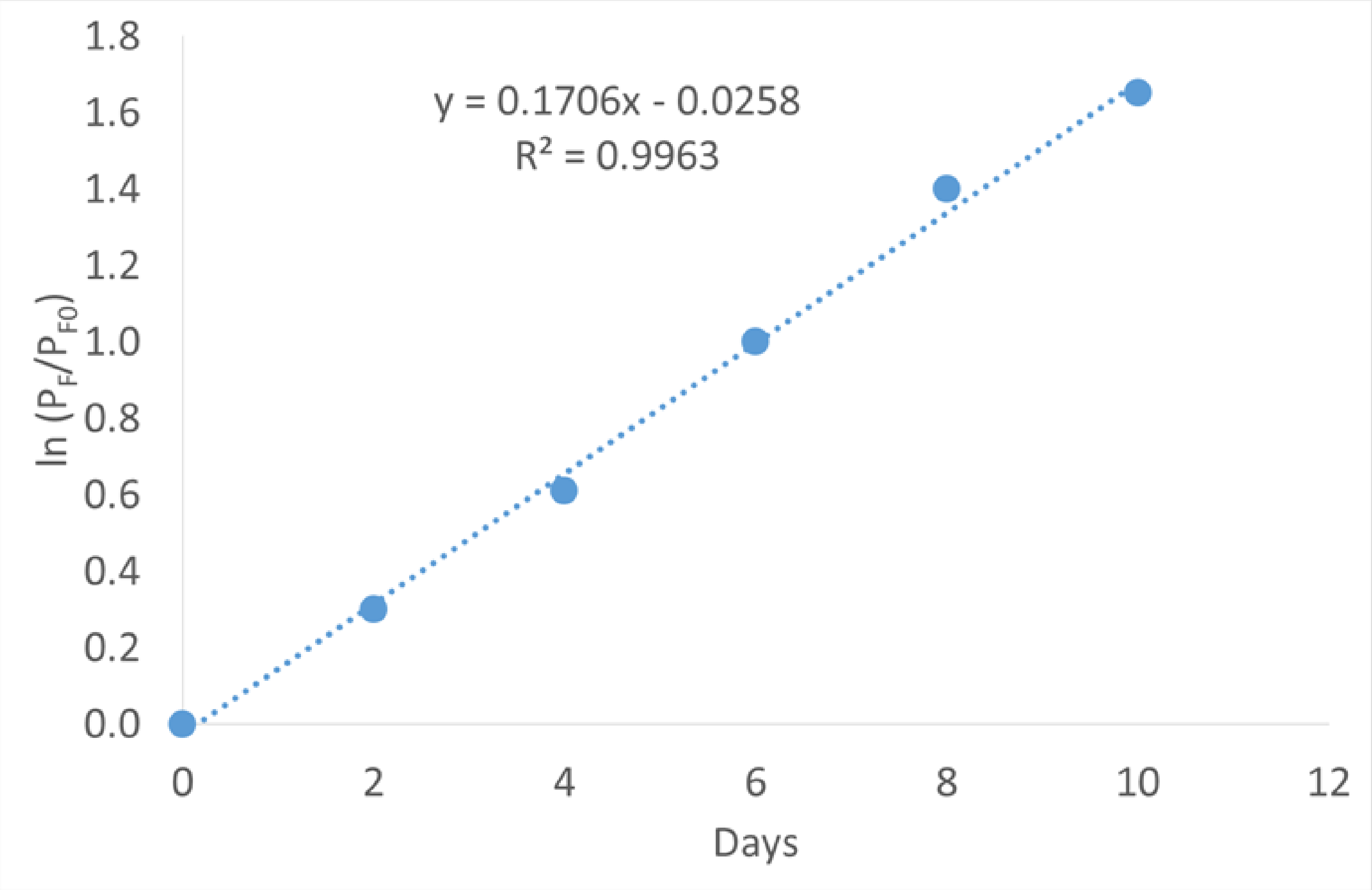


Fig. 1: Correlation of data to obtain the rate constant

- 0.1706 per day or 2.39 per fourteen days
- The latter value compares with the transmission rate of 2.2 reported by Sun et al. (2020).

Modelling results – model validation

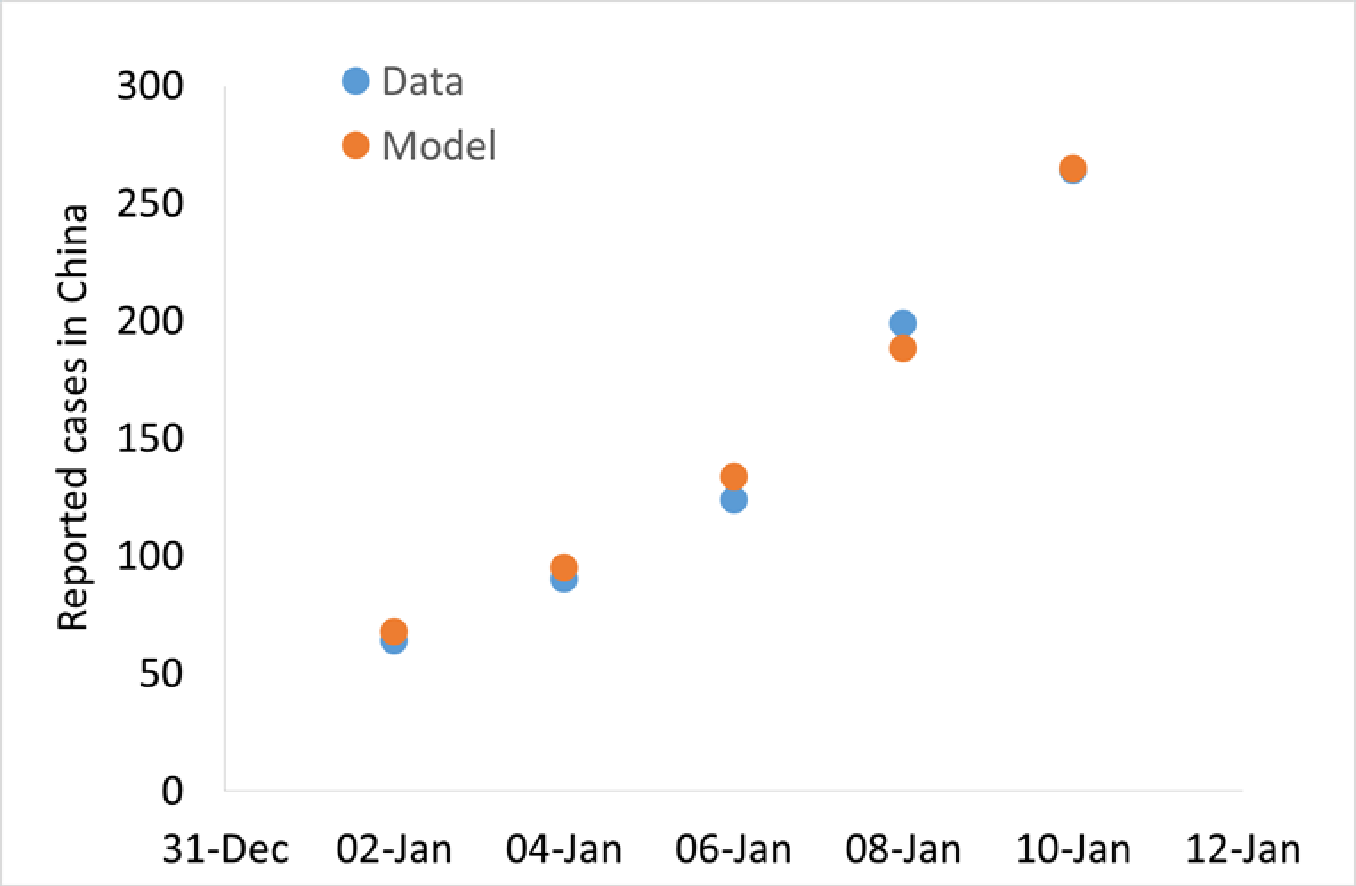
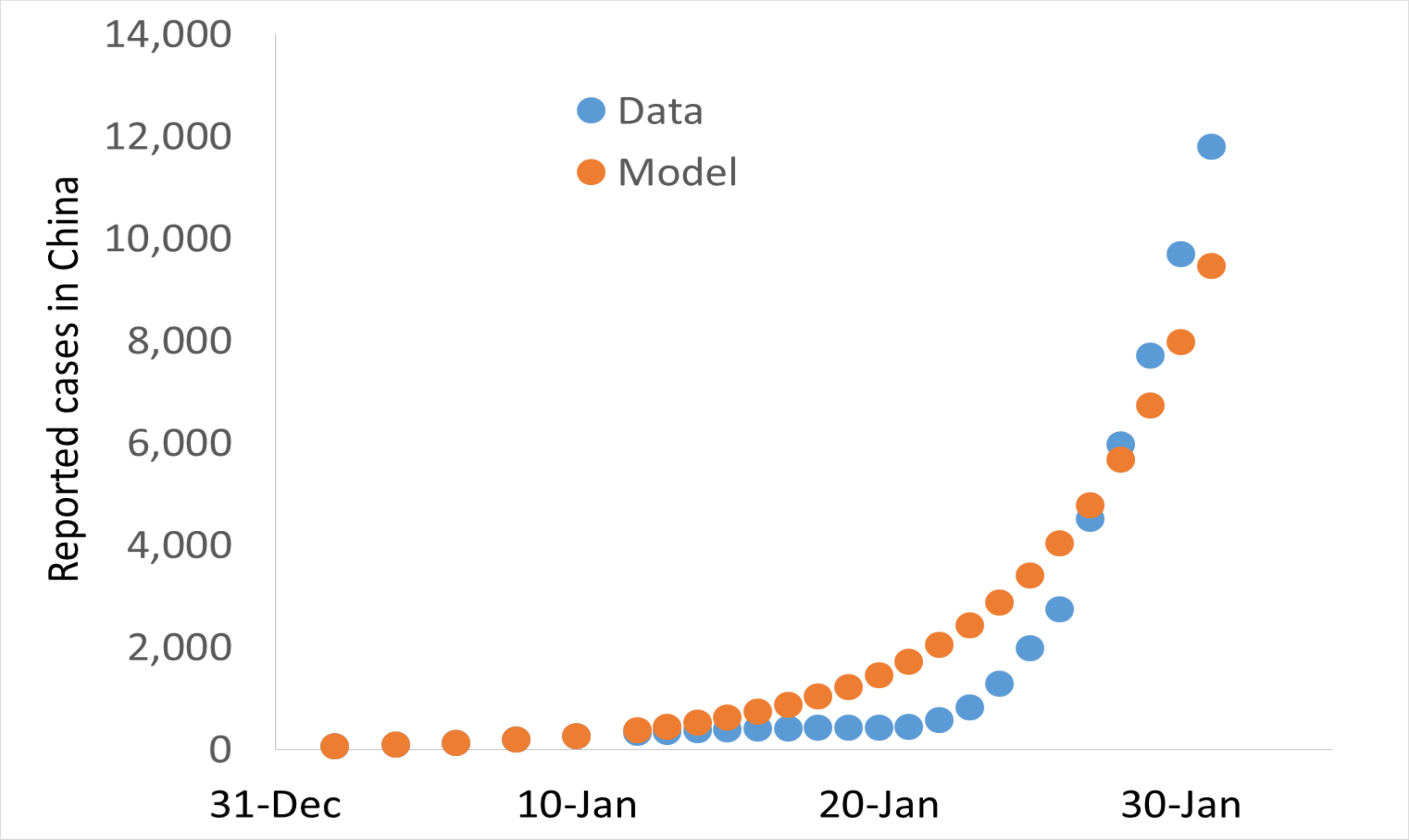


Fig. 2: Model predictions of reported cases of covid-19 in China

- The remaining data of COVID-19 cases reported in China in the period 01 – 11 January 2020 are used to validate the model.
- As shown, the model gives excellent predictions of the reported cases of covid-19 in China.

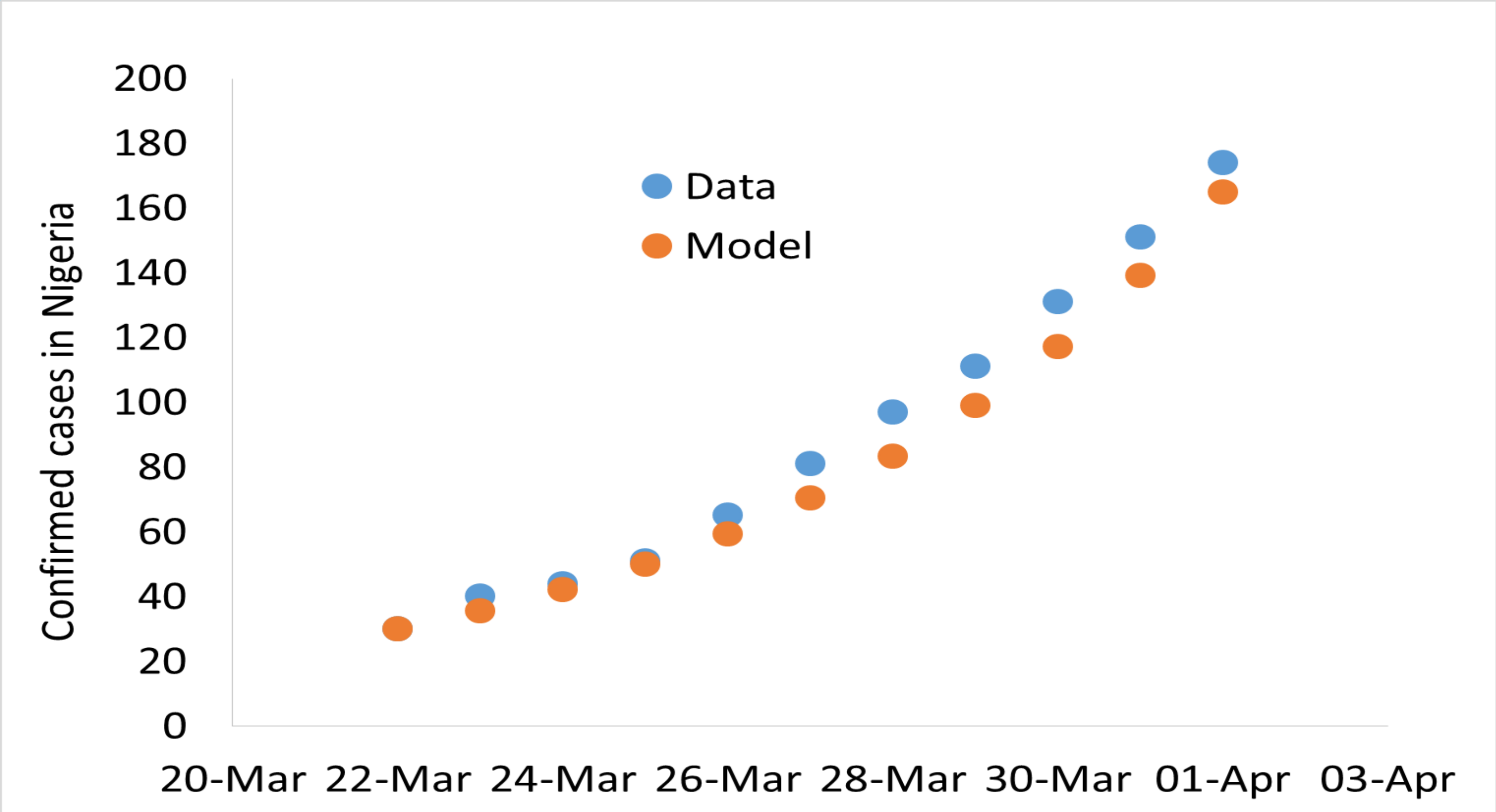
Modelling results – model validation



- A good trend
- Early deviation due to emigrants from China.
- Influx of carriers back to China made later predictions reasonable.

Fig. 3: Covid-19 in China in the period of January 2020.

Modelling results – Nigerian case



- The same value of the exponential constant as for China.
- Able to give good predictions o the cases in Nigeria in March 2020.

Fig. 4: Model predictions of reported cases of covid-19 in Nigeria after border closure

Modelling results – Nigerian case after lockdown

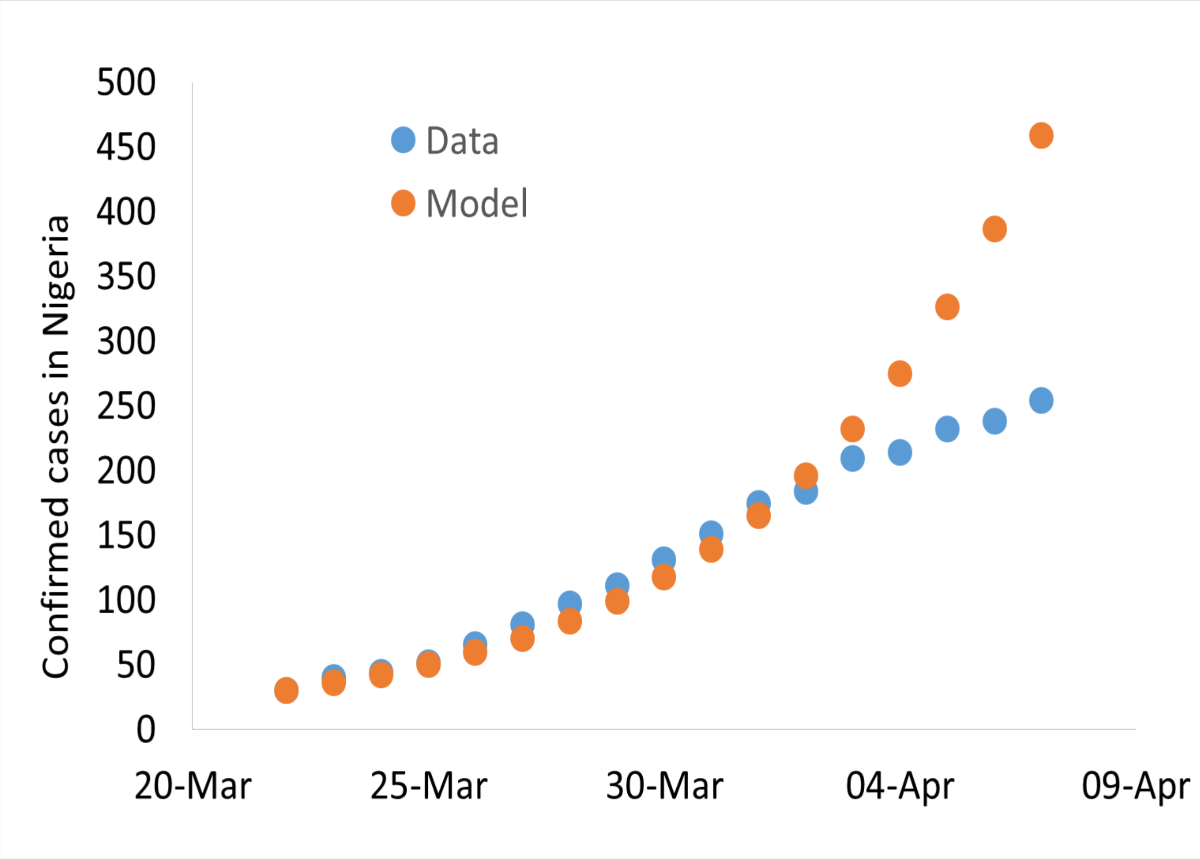


Fig. 5: Model predictions of reported cases of covid-19 in Nigeria after lockdown

- After lockdown and other prevention and control measures in place, the predictions diverge from real data.

Comparison of parameter values

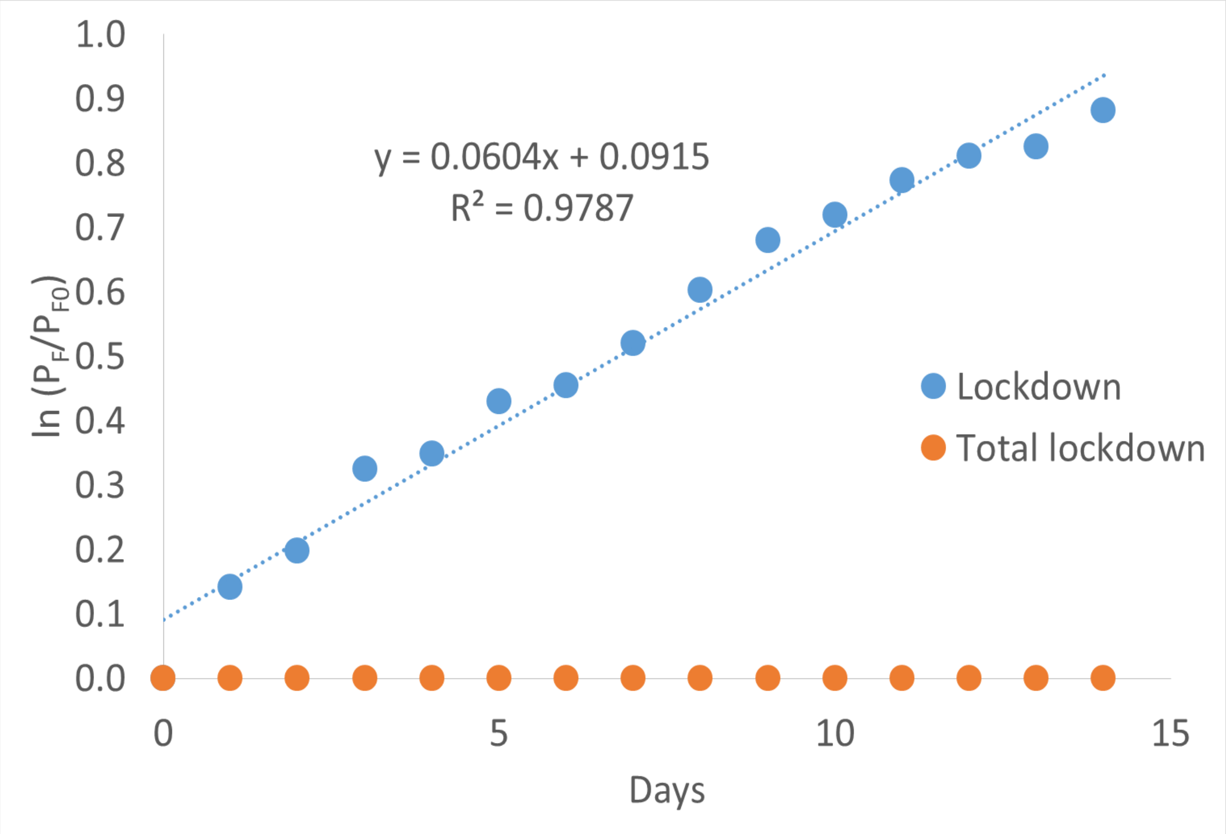


Fig. 6: Parameter values under lockdown

- The value of the exponential constant has decreased from 0.1706 to 0.0605, about one-third of the original value.
- Total lockdown would even make the spread negligible as expected.

Conclusions

- This modelling and its parameters can therefore be employed to check the effectiveness of various measures to mitigate the spread of covid-19.
- Since the exponential constant decreases with time as measures are put in place, the model can be improved by replacing A with a function that decreases with time.

References

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Thank you …