PREDICTION OF DAILY NEW COVID-19 CASES IN EGYPT USING ARTIFICIAL NEURAL NETWORKS

*Dr. Smartson. P. NYONI[1], Thabani NYONI[2], Tatenda. A. CHIHOHO[3]

[1]*ZICHIRe Project, University of Zimbabwe, Harare, Zimbabwe*
[2]*Department of Economics, University of Zimbabwe, Harare, Zimbabwe*
[3]*Department of Economics, University of Zimbabwe, Harare, Zimbabwe*
**Corresponding Author*

ABSTRACT

Modeling and forecasting methods are increasingly becoming very important in the field of Public Health. Different methods have been applied and these include ARIMA models, single equation models, exponential smoothing models, simultaneous equation models, VAR models, SEIR models and Machine learning methods. Machine learning methods are superior in the analysis of complex data hence most suitable in the field of Medicine which is usually characterized with huge and complex data sets. Algorithms for machine learning include Artificial neural networks (ANNs), Support vector Machine (SVM), Decision trees and Ensembles. In this study we choose to apply the ANN model (multilayer perceptron) because of its popularity and simplicity. ANN (12,12,1) model is used and the residual graph and model evaluation criteria (error, MSE, MAE) indicate that the model is stable and ideal for forecasting daily new coronavirus infections in Egypt. Study findings indicate that the projected daily new corona virus (covid-19) cases will sharply rise from November 1,2020(208 cases) to around 3December 2020(1536 cases) and then descend to equilibrium level of 1400 daily new infections until 30April 2021.However, if an effective COVID-19 vaccine (Positive shock) is made available in the out of sample period daily new cases will drop sharply. The study recommends continuous health education among communities, wearing of face masks, regular hand-washing, physical distancing, scaling up covid-19 PCR testing and tightening restrictions in covid -19 hot spot regions.

Keywords: - *ANN, COVID-19, Forecasting*

INTRODUCTION

Covid-19 was first reported in Wuhan City, Hubei Province of China in December 2019.On the 11th of March 2020, WHO declared the disease a pandemic. Egypt reported its first case on the 14th of February 2020(Desouky, 2020). This pandemic is injuring not only health organizations of several countries but also the financial prudence universal (Hussein et al, 2020). The Egyptian government responded early to the outbreak despite being threatened by GDP decline and income losses. By mid-March several measures had been instituted to contain the spread of the disease (Nosier &Salah, 2020). Covid-19 is transmitted from person to person by close contact (within 6 feet) via the respiratory secretions in coughs and sneezes or by touching contaminated surfaces or objects. Old age and preexisting chronic illnesses have been identified as potential risk factors for severe disease and mortality. (Guan et al, 2020). The incubation period of the

virus is 2-14 days with 80% of patients having mild symptoms. About 20% of the patients develop severe disease with symptoms such as shortness of breath, sepsis, septic shock and organ failure and can be fatal in about 2% (Zhu et al, 2020). WHO recommends prevention of spread of the virus by protecting healthcare workers and patients' contacts. Primary preventive measures include regular handwashing, physical distancing and the respiratory hygiene (Gan et al, 2020). The main purpose of the study is to model and forecast daily new corona virus infections in Egypt in order to guide policy and decision making and national health response to the disease.

LITERATURE REVIEW

Table 1: Literature Review

Author(s)	Study period	Method	Major findings
Saba & Elsheikh (2020)	1March 2020 to 10May 2020	ARIMA, NARANN	Forecasted cases showed a good agreement with officially reported cases.
Amar et al (2020)	15February ,2020 to 15June 2020	Logit regression, exponential polynomial regression, quadratic,3^{rd},4^{th} ,5^{th} & 6^{th} degree polynomial regression models	The epidemic peak is 22 June,2020 and could reach the final time on 8September 2020.the result indicate that the COVID-19 epidemic would not end so quickly in Egypt.
Desouky E.D.E (2020)	4February 2020 to 17 April 2020	SIR, SEIR compartmental models	The epidemic peak is likely to be mid-June 2020.the earliest peak to be 20May and latest peak could be on 18July 2020.
Anwar &Mokhtar (2020)	14February 2020 to 11May 2020.	SEIR compartmental model	The highest calculated case fatality rate is 7.7%, the number of hospitalized individuals is expected to peak mid-June 2020 with the peak of hospitalized cases of 20,126 and total expected deaths

			12303
Nosier Salah (2020)	14Feb 2020 to 15 September ,2020	ARIMA, ARDL Google community mobility Reports (GCMR)	Mobility of the population is affecting the incidence of new cases of covid-19 significantly over the study period. The total number of infections on Nov 7,2020 is expected to reach 102,352 cases and total death toll to be 5938

METHOD

This paper applies the multi-layer perceptron neural network type of the ANN approach in order to predict daily new COVID-19 infections in Egypt. The particulary applies the ANN (12, 12, 1) model and chooses the more efficient hyperbolic tangent function as the activation function.

Data Issues

This study is based on daily new COVID-19 cases (referred to as ECG series in this study) for all age groups in Egypt. The data covers the period 14 February 2020 to 31 October 2020 while the out-of-sample forecast covers the period November 2020 to April 2021. All the data employed in this paper was gathered from the COVID-19 data repository prepared by the CSSE at JH University.

FINDINGS OF THE STUDY

DESCRIPTIVE STATISTICS

Table 2: Descriptive statistics

Mean	Median	Minimum	Maximum
412.09	167.00	0.00000	1774.0
Std. Dev.	C.V.	Skewness	Ex. kurtosis
489.12	1.1869	1.3483	0.42792
5% Perc.	95% Perc.	IQ range	Missing obs.
0.00000	1532.7	531.00	0

ANN MODEL SUMMARY FOR COVID-19 DAILY CASES IN EGYPT

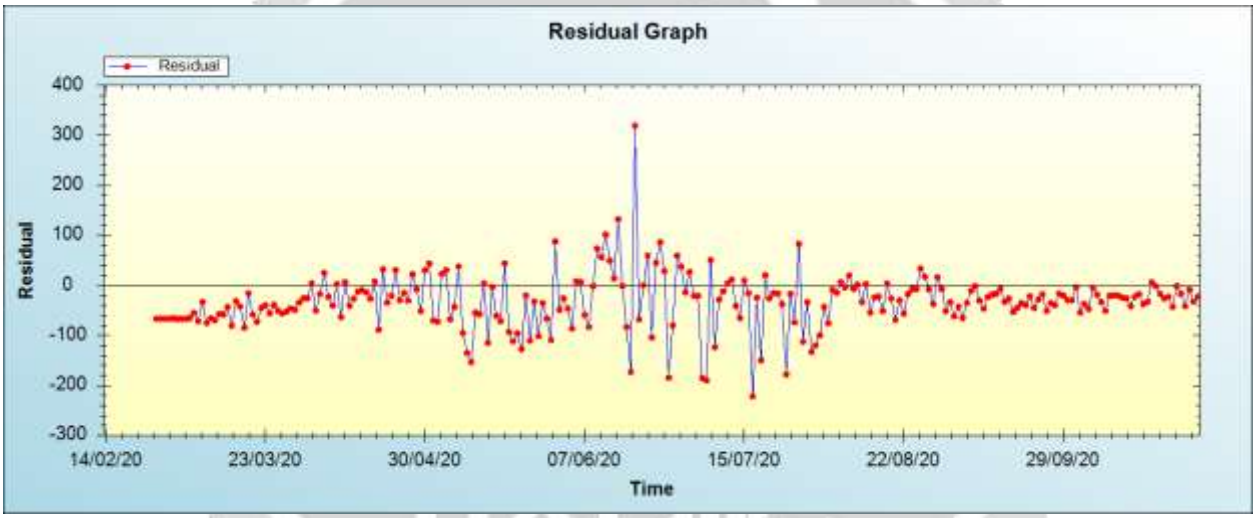
Table 3: ANN model summary

Variable	ECG
Observations	231 (After Adjusting Endpoints)

Neural Network Architecture:	
Input Layer Neurons	12
Hidden Layer Neurons	12
Output Layer Neurons	1
Activation Function	Hyperbolic Tangent Function
Back Propagation Learning:	
Learning Rate	0.005
Momentum	0.05
Criteria:	
Error	0.064009
MSE	3979.629779
MAE	47.054818

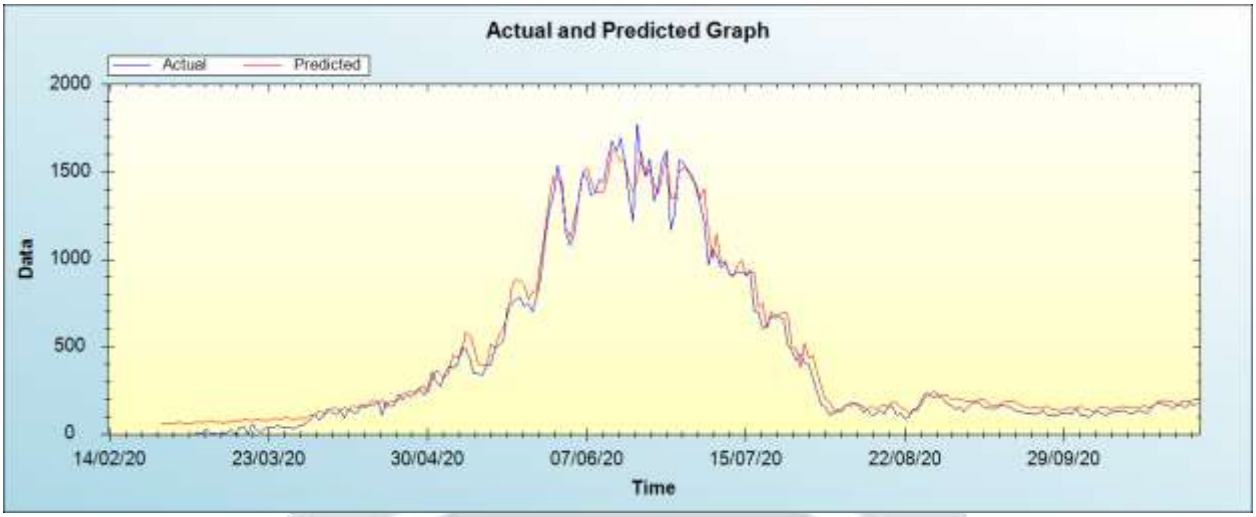
Residual Analysis for the ANN model

Figure 1: Residual analysis



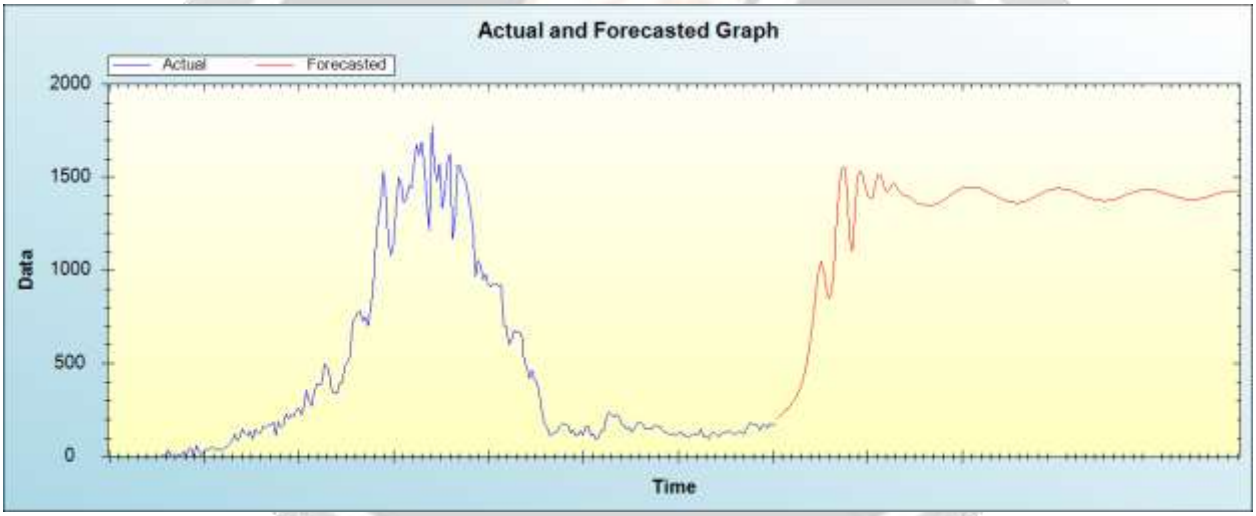
In-sample Forecast for ECG series

Figure 2: In-sample forecast for the ECG series



Out-of-Sample Forecast for ECG: Actual and Forecasted Graph

Figure 3: Out-of-sample forecast for ECG: actual and forecasted graph



Out-of-Sample Forecast for ECG: Forecasts only

Table 4: Predicted ECG

Day/Month/Year	Forecasted daily new cases
01/11/20	208.1407
02/11/20	216.5553
03/11/20	233.3050
04/11/20	250.0515
05/11/20	256.7228

06/11/20	281.8242
07/11/20	298.8655
08/11/20	312.6797
09/11/20	348.8162
10/11/20	377.3448
11/11/20	422.1975
12/11/20	485.6434
13/11/20	555.8915
14/11/20	653.3593
15/11/20	772.0613
16/11/20	897.7049
17/11/20	1005.4330
18/11/20	1046.9281
19/11/20	994.7543
20/11/20	889.1648
21/11/20	845.4377
22/11/20	883.1013
23/11/20	1030.5929
24/11/20	1276.4691
25/11/20	1450.5011
26/11/20	1543.2755
27/11/20	1558.3106
28/11/20	1434.6385
29/11/20	1179.6432
30/11/20	1103.5819
01/12/20	1290.6980

02/12/20	1491.9667
03/12/20	1536.8360
04/12/20	1515.3638
05/12/20	1462.3763
06/12/20	1401.8937
07/12/20	1389.0176
08/12/20	1385.3848
09/12/20	1457.8779
10/12/20	1515.6041
11/12/20	1513.2301
12/12/20	1474.8666
13/12/20	1428.6909
14/12/20	1425.4956
15/12/20	1442.5043
16/12/20	1469.2067
17/12/20	1457.4523
18/12/20	1436.6138
19/12/20	1418.0004
20/12/20	1400.6371
21/12/20	1399.2679
22/12/20	1398.2171
23/12/20	1393.5608
24/12/20	1376.1422
25/12/20	1367.6989
26/12/20	1358.7360
27/12/20	1353.5416

28/12/20	1354.3452
29/12/20	1351.4202
30/12/20	1349.3593
31/12/20	1348.4607
01/01/21	1353.4423
02/01/21	1356.5255
03/01/21	1363.9909
04/01/21	1372.6943
05/01/21	1380.5970
06/01/21	1390.9152
07/01/21	1400.9257
08/01/21	1410.7619
09/01/21	1419.1969
10/01/21	1428.8158
11/01/21	1435.9038
12/01/21	1441.3059
13/01/21	1446.1790
14/01/21	1448.5271
15/01/21	1449.5486
16/01/21	1449.2898
17/01/21	1447.8790
18/01/21	1444.3076
19/01/21	1440.2181
20/01/21	1435.1579
21/01/21	1428.6334
22/01/21	1422.0290

23/01/21	1414.9547
24/01/21	1407.5094
25/01/21	1399.9512
26/01/21	1392.9513
27/01/21	1385.9778
28/01/21	1379.6117
29/01/21	1374.3286
30/01/21	1369.7188
31/01/21	1366.2615
01/02/21	1364.1017
02/02/21	1363.2863
03/02/21	1363.6945
04/02/21	1365.6928
05/02/21	1369.0257
06/02/21	1373.5014
07/02/21	1379.2260
08/02/21	1385.8010
09/02/21	1392.9627
10/02/21	1400.4571
11/02/21	1408.0276
12/02/21	1415.2107
13/02/21	1421.8454
14/02/21	1427.7366
15/02/21	1432.5710
16/02/21	1436.3244
17/02/21	1438.9260

18/02/21	1440.3015
19/02/21	1440.4520
20/02/21	1439.4969
21/02/21	1437.4509
22/02/21	1434.4019
23/02/21	1430.5458
24/02/21	1425.9665
25/02/21	1420.8122
26/02/21	1415.2717
27/02/21	1409.5080
28/02/21	1403.6555
01/03/21	1397.9185
02/03/21	1392.4675
03/03/21	1387.4282
04/03/21	1382.9817
05/03/21	1379.2659
06/03/21	1376.3882
07/03/21	1374.4546
08/03/21	1373.5566
09/03/21	1373.7218
10/03/21	1374.9618
11/03/21	1377.2629
12/03/21	1380.5383
13/03/21	1384.6758
14/03/21	1389.5279
15/03/21	1394.9016

16/03/21	1400.5766
17/03/21	1406.3356
18/03/21	1411.9517
19/03/21	1417.2074
20/03/21	1421.9262
21/03/21	1425.9545
22/03/21	1429.1728
23/03/21	1431.5057
24/03/21	1432.9128
25/03/21	1433.3795
26/03/21	1432.9278
27/03/21	1431.6085
28/03/21	1429.4875
29/03/21	1426.6554
30/03/21	1423.2201
31/03/21	1419.2969
01/04/21	1415.0116
02/04/21	1410.5000
03/04/21	1405.8979
04/04/21	1401.3415
05/04/21	1396.9693
06/04/21	1392.9117
07/04/21	1389.2913
08/04/21	1386.2220
09/04/21	1383.8031
10/04/21	1382.1149

11/04/21	1381.2192
12/04/21	1381.1533
13/04/21	1381.9255
14/04/21	1383.5159
15/04/21	1385.8732
16/04/21	1388.9141
17/04/21	1392.5266
18/04/21	1396.5741
19/04/21	1400.9004
20/04/21	1405.3389
21/04/21	1409.7216
22/04/21	1413.8868
23/04/21	1417.6877
24/04/21	1420.9988
25/04/21	1423.7194
26/04/21	1425.7751
27/04/21	1427.1194
28/04/21	1427.7320
29/04/21	1427.6169
30/04/21	1426.8013

Figure 1 shows that the data is positively skewed and platykurtic (asymmetrically distributed, not normally distributed) over the study period. The minimum and maximum number of daily new covid-19 infections is 0 and 1774 respectively. The average daily new infections are 412. The applied model simulates the observed data very well as shown in Figure3. The residual graph and model evaluation criteria show that the applied ANN (12,12,1) model is stable and suitable for forecasting daily new covid-19 cases over the out of sample period. The projections indicate that new daily corona virus infections will sharply rise from November 1, 2020 to 3 December 2020, that is from 208 to approximately 1536 cases per day. After 3 December 2020 the daily new infections are projected to descend to an equilibrium level of around 1400 daily new infections until April 30, 2021.

CONCLUSION & RECOMMENDATIONS

Egypt has not been spared by the corona virus pandemic. Many people have suffered from the disease and lost their lives. The government should continue health education among communities, scale up PCR testing through mobile testing services, regular hand washing, physical distancing, wearing facemasks and tighten restrictions in cities where daily new infections are increasing as study findings indicate a projected increase of daily new corona virus infections which will reach equilibrium point of 1400 new cases after 3December 2020 until the end of April 2021.However, if an effective vaccine is availed during the out of sample period, a positive shock is experienced which will be characterized by a sharp drop in the number of daily new COVID-19 cases.

REFERENCES

[1] COVID-19 Repository By the Center for Systems Science and Engineering (CSSE) at Johns Hopkins University.

[2] Desouky E.D. E (2020). Prediction of the Epidemic Peak of COVID-19 in Egypt.medRxiv:/pp:1-9

[3] Dong, E., *et al*. (2020). An Interactive Web-based Dashboard to Track COVID-19 in Real Time, *Lancet Infectious Diseases*, 20 (5): 533 – 534.

[4] Gan et al (2020). Preventing intrahospital infection and transmission of Covid-19 in healthcare workers. Safety and Health at work,11,241.

[5] Hussein et al (2020). Survival and 30days hospital outcome in hospitalized Covid-19 patients in Upper Egypt: Multicenter study. medRxiv:/pp:1-19.

[6] Nosier & Salah (2020). Forecasting Covid-19 infections and deaths Horizon in Egypt.medRxiv:/pp:1-24.

[7] Zhu et al (2020). A novel corona virus from patients with pneumonia in China. New England Journal of Medicine,382,727-733.