PREDICTION OF DAILY NEW COVID-19 CASES IN THE UNITED KINGDOM (UK) USING ARTIFICIAL NEURAL NETWORKS

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ABSTRACT

In this empirical article, the ANN approach was applied to analyze daily new COVID-19 cases in the UK. The employed data covers the period 31 January 2020 to 31October 2020 and the out-of-sample period ranges over the period November 2020 to April 2021. The residuals and forecast evaluation criteria (Error, MSE and MAE) of the applied model indicate that the model is stable in forecasting daily new COVID-19 cases in the United Kingdom. The results of the study indicate that, without an effective COVID-19 vaccine or treatment; daily COVID-19 case volumes will continue to surge in the country. Despite approving the public use of a COVID-19 vaccine, the UK government should continue to enforce all the recommended WHO guidelines on prevention and control of the COVID-19 epidemic.

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

INTRODUCTION

The first case of the Novel Coronavirus, COVID-19 was reported in the United Kingdom on 31 January 2020 (Davies et al, 2020; Dropkin, 2020). However, the UK government did not respond early to the rapidly spreading epidemic (UK Government, 2020). In the early stages of the outbreak the government focused on containment measures which included rapid case detection and isolation of COVID-19 positive cases which was achieved through testing and contact tracing. In March, 2020 it was very clear that there were high COVID-19 community transmissions and it was almost definite that the health delivery system would be choked because of a sudden increase in demand for health care resources such as bedding, ventilators, ICU units, clinical and non-clinical staff and emergency ambulance services (Keeling et al, 2020). The government introduced social distancing measures in order to curb the local transmissions and minimize deaths. By 29 July 2020 there were 301455 confirmed cases and more than 45 961 deaths (Griffiths et al, 2020). COVID-19 is a viral infection which is caused by a novel corona virus, SARS CoV-2 which was previously not found in humans. There are several clinical symptoms of the disease such as fever, coughing, shortness of breath, sore throat and chest pain. The diagnosis of the condition is through asking about the presence of the above symptoms, history of contact with a COVID-19 patient or living in a community where there are reported cases of the virus and confirmatory lab test, the PCR test. The severity of the clinical disease depends on many factors. The pre-existence of chronic medical conditions, elderly people above 65 years and being male have been been found to be risk factors of developing severe disease.

The pandemic has many effects on health systems, economies and on individuals. The entire world has been affected by global economic meltdown characterized by health systems being overwhelmed due to lack of resources. At individual level the virus has caused high morbidity and mortality. Lockdown, social distancing and quarantine measures have resulted in psychiatric disorders to some people (Galea et al, 2020; Elbay et al, 2020; Golderberg, 1988; Huang & Zhao, 2020; Kawohl & Nordt, 2020). Much more suffer from the emotional burdens of loneliness (Banerjee & Rai, 2020; Hwang et al, 2020; Killgore et al, 2020). In addition disruption of social lives has led to loneliness (Jia etal, 2020). In this study we model and forecast the daily new COVID-19 cases in the UK using the ANN model. The findings of this piece of work will guide policy and stimulate an appropriate evidenced-based national response to the epidemic.

LITERATURE REVIEW

Author(s)/year	Study period	Method	Major Findings
Danon etal (2020).	January 2020-April 2020.	Metapopulation model	Seasonal changes in transmission rate substantially impact the timing and size of the epidemic peak as well as the total attack rate. COVID-19 will peak 4 months after the start of the person-person transmission in England and Wales.
Keeling etal (2020).	1February 2020-1April 2020	SEIR model: age structured compartmental model.	Significant relaxation of social distancing measures from 7 May 2020 onwards could lead to a rapid resurgence of COVID-19 disease and the health system would be overwhelmed. The model projected serous demand for critical care resources during the course of the pandemic.
Dropkin G (2020)	30 January 2020-31March 2020.	SEIR model.	The basic reproduction number of 6.94 estimate is compatible with international estimates

			but over twice the value quoted by the UK government. An earlier lockdown could have saved many thousand lives.
Janice etal (2020)	16March 2020-26April 2020	Logistic regression model.	There are specific high-risk pre-existing comorbidities for COVID-19 hospitalization and related deaths in community based older men and women

METHOD

This paper applies the multi-layer perceptron neural network type of the ANN approach in order to predict daily COVID-19 infections in UK. This study particularly 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 K series in this study) for all age groups in the United Kingdom (UK). The data covers the period January 31 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 research paper was gathered Johns Hopkins University (USA).

FINDINGS OF THE STUDY

DESCRIPTIVE STATISTICS

Table 1: Descriptive statistics

Mean	Median	Minimum	Maximum
3690.2	1332.0	0.00000	26707.
Std. Dev.	C.V.	Skewness	Ex. Kurtosis
5628.5	1.5253	2.3937	4.9519
5% Perc.	95% Perc.	IQ range	Missing obs.
1.0000	19760.	3426.0	0

ANN MODEL SUMMARY FOR COVID-19 DAILY CASES IN UK

Table 2: ANN model summary

Variable	K
Observations	263 (After Adjusting Endpoints)
Neural Network Architecture:	
Input Layer Neurons	12

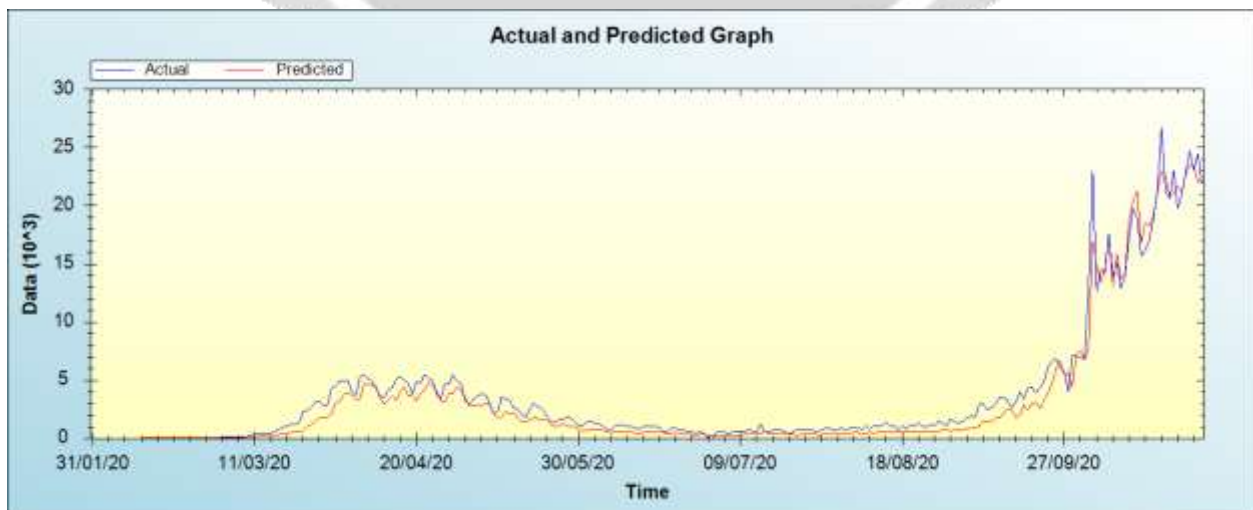| Hidden Layer Neurons	12
Output Layer Neurons	1
Activation Function	Hyperbolic Tangent Function
Back Propagation Learning:	
Learning Rate	0.005
Momentum	0.05
Criteria:	
Error	0.067674
MSE	1008207.392444
MAE	688.051004

Residual Analysis for the ANN model

Figure 1: Residual analysis
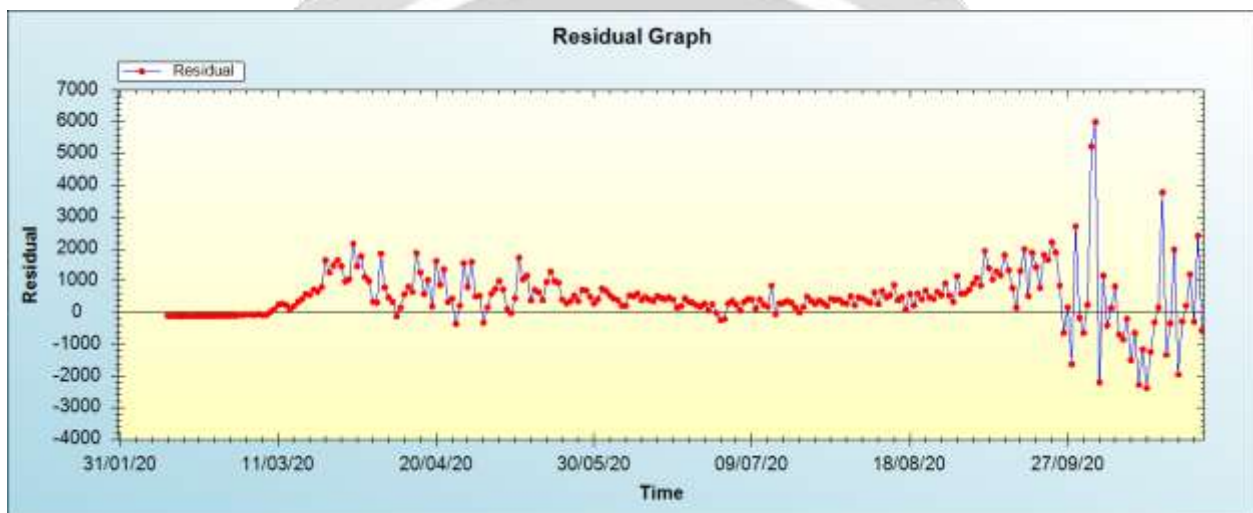
In-sample Forecast for K

Figure 2: In-sample forecast for the K series

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

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

Out-of-Sample Forecast for K: Forecasts only

Table 3: Tabulated out-of-sample forecasts

Day/Month/Year	Forecasted daily new COVID-19 cases
01/11/20	20384.3829
02/11/20	17056.9658
03/11/20	18806.9782
04/11/20	20152.7231
05/11/20	20553.5135
06/11/20	20225.0372
07/11/20	17589.3442
08/11/20	13709.8788
09/11/20	13576.5136
10/11/20	15358.5434
11/11/20	14816.2492
12/11/20	14695.8883

13/11/20	14015.9549
14/11/20	13820.8367
15/11/20	14806.5713
16/11/20	15358.6046
17/11/20	15656.1958
18/11/20	16068.1474
19/11/20	17606.9748
20/11/20	20109.0619
21/11/20	21253.5087
22/11/20	21491.6614
23/11/20	21880.4973
24/11/20	21638.6254
25/11/20	21475.4687
26/11/20	21937.4548
27/11/20	22510.3132
28/11/20	22943.3520
29/11/20	23241.5917
30/11/20	23366.6702
01/12/20	23189.2132
02/12/20	22584.5693
03/12/20	22176.3762
04/12/20	22139.5426
05/12/20	22143.4537
06/12/20	22148.2943
07/12/20	21925.4631
08/12/20	21121.6576

09/12/20	19537.6144
10/12/20	17377.2739
11/12/20	15516.6153
12/12/20	14431.0614
13/12/20	13857.0395
14/12/20	13396.9151
15/12/20	12935.7865
16/12/20	13061.8421
17/12/20	14095.8128
18/12/20	14769.5687
19/12/20	14297.8365
20/12/20	13942.5778
21/12/20	14600.9095
22/12/20	16162.9366
23/12/20	18601.1977
24/12/20	20831.5308
25/12/20	21496.4626
26/12/20	21275.1236
27/12/20	21152.2530
28/12/20	21257.0211
29/12/20	21297.0498
30/12/20	21696.1345
31/12/20	22405.5446
01/01/21	22998.2895
02/01/21	23268.9319
03/01/21	23226.3131

04/01/21	22862.1642
05/01/21	22321.1256
06/01/21	22092.9359
07/01/21	22283.2481
08/01/21	22516.9354
09/01/21	22513.9729
10/01/21	22164.3062
11/01/21	21237.9841
12/01/21	19589.8981
13/01/21	17601.4893
14/01/21	15996.3308
15/01/21	14959.4170
16/01/21	14211.2774
17/01/21	13514.7576
18/01/21	13021.9255
19/01/21	13306.6119
20/01/21	14209.1681
21/01/21	14492.6492
22/01/21	14033.5909
23/01/21	13981.0271
24/01/21	14736.4808
25/01/21	16033.0807
26/01/21	18231.1774
27/01/21	20613.7331
28/01/21	21340.0744
29/01/21	21137.9376

30/01/21	21232.5808
31/01/21	21339.8196
01/02/21	21252.7619
02/02/21	21638.0537
03/02/21	22380.2338
04/02/21	22951.4355
05/02/21	23229.8932
06/02/21	23257.4560
07/02/21	22994.4833
08/02/21	22441.6878
09/02/21	22167.1775
10/02/21	22331.9584
11/02/21	22517.3816
12/02/21	22509.8167
13/02/21	22229.2334
14/02/21	21413.9739
15/02/21	19878.3798
16/02/21	17922.4383
17/02/21	16241.8875
18/02/21	15090.8358
19/02/21	14272.3156
20/02/21	13586.2544
21/02/21	13079.1662
22/02/21	13219.7771
23/02/21	14027.6575
24/02/21	14471.5982

25/02/21	14138.2827
26/02/21	13979.5438
27/02/21	14586.8958
28/02/21	15768.6709
01/03/21	17813.8682
02/03/21	20305.1246
03/03/21	21307.1124
04/03/21	21193.6830
05/03/21	21224.4500
06/03/21	21342.8205
07/03/21	21255.4348
08/03/21	21550.0567
09/03/21	22266.7329
10/03/21	22872.8514
11/03/21	23208.3836
12/03/21	23275.1200
13/03/21	23066.3720
14/03/21	22528.4562
15/03/21	22178.5553
16/03/21	22285.2615
17/03/21	22485.9251
18/03/21	22518.3558
19/03/21	22297.4047
20/03/21	21585.4034
21/03/21	20159.0085
22/03/21	18221.7507

23/03/21	16451.4935
24/03/21	15221.3664
25/03/21	14372.9193
26/03/21	13683.6937
27/03/21	13125.9858
28/03/21	13130.2019
29/03/21	13891.1325
30/03/21	14474.0875
31/03/21	14217.3250
01/04/21	13952.8556
02/04/21	14445.2322
03/04/21	15546.1917
04/04/21	17437.8764
05/04/21	19994.9217
06/04/21	21269.9959
07/04/21	21228.6664
08/04/21	21192.9407
09/04/21	21340.3441
10/04/21	21261.5096
11/04/21	21464.0169
12/04/21	22155.5511
13/04/21	22796.2919
14/04/21	23178.8218
15/04/21	23277.7323
16/04/21	23121.0065
17/04/21	22611.6426

18/04/21	22196.0155
19/04/21	22249.1885
20/04/21	22464.0426
21/04/21	22527.7459
22/04/21	22354.7533
23/04/21	21735.4670
24/04/21	20416.8053
25/04/21	18518.4453
26/04/21	16681.3675
27/04/21	15376.1783
28/04/21	14487.1480
29/04/21	13784.3386
30/04/21	13188.0831

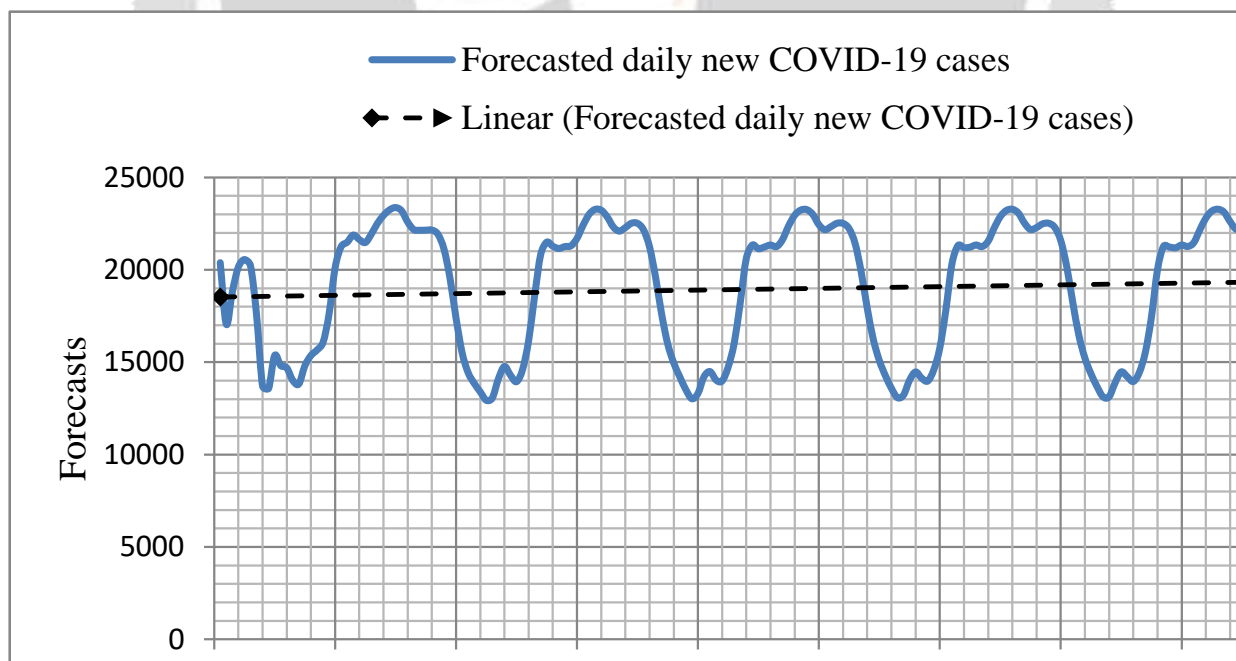Figure 4: Graphical presentation of out-of-sample forecasts

Table 1 shows that over the study period the minimum and maximum daily new COVID-19 cases are 0 and 26707 respectively. The average daily new cases of COVID-19 are 3690 cases. The residual graph and model evaluation criteria indicate that the applied model is stable and suitable for forecasting daily new COVID-19cases in the UK. Our predictions generally indicate

that COVID-19 daily cases will continue to rise in the out-of-sample period. However, with the intention of the UK government to roll out a COVID-19 vaccine by mid-December 2020, we then expect the daily confirmed cases of COVID-19 to gradually decline.

CONCLUSION & RECOMMENDATIONS

The COVID-19 virus is rapidly spreading in the UK and is accompanied by high morbidity and mortality. As the epidemic progresses over time increased demand for critical care resources is observed. Social distancing measures are playing a significant role in controlling the spread of the virus. There is need for the UK government to set aside more resources for health especially critical care resources. Despite the fact that the UK has approved the public use of a COVID-19 vaccine, the government should continue to enforce all the recommended WHO guidelines on prevention and control of the COVID-19 epidemic.

REFERENCES

[1] (COVID-19 UK Government. Coronavirus) in the UK. Available online at: https://coronavirus.data.gov.uk/

[2] Banerjee& Rai (2020). Social isolation in Covid-19: the impact of loneliness. Int. J. Soc. Psychiatry 002076402092226. https://doi.org/10.1177/0020764020922269

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

[4] Davies etal (2020). Effects of non-pharmaceutical interventions on COVID-19 cases, deaths, and demand for hospital services in the UK: a modeling study. Lancet Public Health. 5: 375-85.

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

[6] Dropkin.G(2020). COVID-19 UK lockdown Forecasts and R0. Frontiers in Public Health 8 (256): 1-8.

[7] Elbay etal (2020) Depression, anxiety, stress levels of physicians and associated factors in Covid-19 pandemics. Psychiatry Res 113130. https://doi.org/10.1016/j.psychres.2020.113130.

[8] Galea etal (2020). The mental health consequences of COVID-19 and physical distancing: the need for prevention and early intervention. JAMA Intern. Med. https://doi.org/10.1001/jamainternmed.2020.1562.

[9] Golderberg, D.P., Williams, P., 1988. A User's Guide to the General Health Questionnaire. Windsor: NFER-Nelson.

[10] Griffiths etal (2020). Determining the optimal strategy for reopening schools, the impact of test and trace interventions, and the risk of occurrence of a second wave of COVID19 epidemic wave in the UK: a modeling study. Lancet Child Adolesc Health 4: 817-27.

[11]   Huang& Zhao (2020). Generalized anxiety disorder, depressive symptoms and sleep quality during COVID-19 outbreak in China: a web-based cross-sectional survey. Psychiatry Res. 288, 112954.

[12]   Hwang etal (2020). Loneliness and SocialIsolationduringtheCOVID-19 Pandemic.Int. Psychogeriatric. 1–15.

[13]   Jia etal (2020). Mental health in the UK during the COVID-19 pandemic: early observations   (preprint).   Public   Glob.   Health. https://doi.org/10.1101/2020.05.14.20102012.

[14]   Kawohl & Nordt (2020). COVID-19, unemployment, and suicide. LancetPsychiatry7, 389–390.

[15]   Keeling etal (2020). Predictions of COVID-19 dynamics in the UK: short-term forecasting and analysis of potential exit strategies.medRxiv pp1-22

[16]   Killgore etal(2020a). Loneliness: a signature mental health concern in the era of COVID-19. Psychiatry Res. 290, 113117.

[17]   Killgore etal(2020b). Psychological resilience during the COVID-19 lockdown. Psychiatry Res. 291, 113216.