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FORECAST OF CORONA VIRUS DISEASE (COVID–19) IN ETHIOPIA BASED ON CONFIRMED CASES UP TO 14TH OCTOBER 2020

ALEMU BEKELE ETICHA[1*]

[1]Department of Statistics, College of Natural and Computational Science, Mizan-Tepi University, Tepi, Ethiopia.

AUTHOR'S CONTRIBUTION

The sole author designed, analysed, interpreted and prepared the manuscript.

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ABSTRACT

An Autoregressive Integrated Moving Average model is a set of statistical models for forecasting time series data. Briefly, Auto regression uses the dependent relationship between an observation and lagged observations; integrated uses of differencing of raw observations; and Moving Average uses the dependency between an observation and a residual error.

The ARIMA (2, 2, 2) forecasted the number of confirmed cases of COVID-19, based on the time between March 2020 and October 2020 at 95% confidence interval. The result of daily report peaked in April 2020 in the country and slightly decreased after April 2020, evidenced by the challenged responses that invested in controlling the pandemic in the country. The maximum, predicted new case per day was 672 and the minimum predicted was 386 cases per day till half of December 2020. Furthermore, the total number of predicted confirmed cases of COVID-19 might reach around 119, 015 until half December 2020.

In general, if the government of Ethiopia ceased controlling mechanisms of COVID-19, then the pandemic may relapse again and affects the country more. Hence, this study suggested that proactive stepladder implements control mechanisms. Thus, all the concerned organizations can develop policies based on the result of the study.

Keywords: COVID-19 trend; COVID-19 new case forecast; ARIMA model; corona virus; pandemic.

1. INTRODUCTION

Human coronavirus infections have been known to cause mild respiratory illness. The three global outbreaks by coronaviruses that led to serious mortality and morbidity were SARS CoV-1, MERS-CoV, and SARS-CoV2. The first epidemic of the twenty first century due to coronavirus was SARS CoV-1. SARS COV-1 infection had a broad array of symptoms with respiratory and gastrointestinal as most frequent and the last known case was reported in 2004. The Middle East respiratory syndrome coronavirus (MERS-CoV) led to the second outbreak in 2012, and case fatality was much higher than SARS-COV-1. MERS-CoV has a wide array of clinical presentations from mild, moderate to severe, and some patients end up with acute respiratory distress syndrome. The third and recent outbreak by severe acute respiratory syndrome coronavirus-2 (SARS-CoV-2) started in December 2019, which leads to a global pandemic. Patients with SARS-CoV2 infection can be asymptomatic or have a range of

**Corresponding author: Email: abestat10@gmail.com;*

symptoms with fever, cough, and shortness of breath being most common. This study focused on SARS-Cov-2 which literally called COVID-19 [1].

The recent outbreak (COVID-19) has developed into a global pandemic as of 4 May 2020, is still in progress [2]. The pandemic first identified in December 2019 in Wuhan, China [3]. Later on, the rapid spread of this pandemic from corner to corner was a sudden shock to the whole world. As of 13 October 2020, more than 38.3 million cases of COVID-19 have been recorded in a total of 2010 countries and regions resulting in more than 1.08 million deaths, while more than 28.8 million people have recovered [4].

In Africa, on 14th February 2020, the first coronavirus case reported. As of 13 October 2020, the first four African countries reporting most cases of Covid-19 were South Africa (693,359), Morocco (156,946), Egypt (104,648), and Ethiopia (85,718) respectively [5].

As of 13 October 2020, number of corona virus cases reported from Ethiopia (85,718) was larger than the cases reported from China (85,591). Thus, Ethiopia is one of the countries that seriously affected by the coronavirus (COVID-19) disease since first case was identified in 13 March 2020. Then up to date, the cases report from the country passes eighty-six thousands. As of 14 October 2020, more than 86.4 thousand confirmed cases of COVID-19 have been registered in Ethiopian and resulting more than 1305 deaths, whereas more than 42,649 individuals recovered [4,5].

Even though well known, measures like hand-washing, keeping social distance, and wearing face masks suggested by public health workers to control the spread of coronavirus, it never ceased transmission still in Ethiopia [6]. According to the study on the distribution of the Coronavirus in the first three months the confirmed case and the death rate increased with the first three months in the country [7]. The death model was done by [8], but the death of the pandemic is about 4% globally. Since the COVID-19 has continued to be a global risk of public health and it needs uttermost effort to monitor the prevalence of the virus, applying prediction methods of the pandemic is argued to be the fundamental requirement of effectively control the prevalence rate [9]. Thus, this study was predicted the new case of COVID-19 in Ethiopia for the next 60 days with the objective to alarms the whole concerned bodies to control the prevalence and threat of this pandemic.

2. METHODS

2.1 Data Set

Across the world, researchers and policymakers look to confirmed counts of cases and deaths to understand and compare the spread of the COVID-19 pandemic. In this study, the data of COVID-19 was extracted and organized from the public health institute daily report until 14th October 2020. Then the data were presented and analyzed by Minitab 12 version. The time series forecast method was applied to show the future 60 days forecast of (COVID-19) in the country. The study design was a register-based trend series analysis on reports of the federal ministry of health on each day from March to the half of October 2020.

2.2 Analytical Methods

In time series, ARIMA modeling is one of the best modeling techniques in trend analysis [2,9]. The ARIMA methods with the help of some parameters and the model expressed as ARIMA (p, d, q). Here, p stands for the order of auto-regression, d signifies the degree of trend difference, and q is the order of moving average [10]. I have applied an ARIMA method to the time series data of confirmed COVID-19 cases in Ethiopia. The model for forecasting future confirmed COVID-19 cases displayed as;

$$ARIMA(p,d,f) = \alpha_1 X_{t-1} + \alpha_2 X_{t-2} + \beta_1 Z_{t-1} + \beta_2 Z_{t-2} + Z_t$$

$$Z_t = X_t - X_{t-1}$$

Where, X_t is the predicted number of confirmed COVID-19 cases at ith day, $\alpha_1, \alpha_2, \beta_1 \, and \, \beta_2$ are parameters whereas Zt is the residual term for ith day. The trend analysis accommodating can be estimated from the previously confirmed cases, and the time series analysis performed for this purpose. Time series forecasting refers to the employment of a model to forecast future data based on previously observed data. In this study, time series analysis was applied to recognize the trends in confirmed COVID-19 cases in Ethiopia from 14 March 2020 to 14 October 2020. Also, predict future cases or deaths from 15 October 2020 until 13 December 2020. The level of statistical significance set at 0.05. A graph plotted for actual confirmed cases predicted confirmed cases concerning time to verify the efficiency of the model [11].

3. RESULTS

3.1 Descriptive Statistics

The description of the corona virus spread in Ethiopia by months was displayed on Tabe1. On 13 March, a first COVID-19 case was announced from Ethiopia by the federal ministry of Ethiopia. By the end of the month, there had been 25 confirmed cases, two recoveries, and no deaths, leaving 23 positive pandemic cases when going into April. By the end of April month, there had been 106 new cases, bringing the total number of confirmed cases to 131. The death toll was 3. The number of recovered patients increased to 59, leaving 69 active pandemic cases.

In May, the pandemic status was 1041 new cases, bringing the total number of confirmed cases to 1172. The death toll rose to 11. The number of recovered patients increased to 209, leaving 952 active coronavirus cases at the end of the month. There were 4674 new cases in June month, raising the total number of confirmed cases to 5846. The death toll rose to 103. The number of recovered patients increased to 2430, leaving 3313 active pandemic cases at the end of the month.

During the July month, there were 11,684 new cases, raising the total number of confirmed cases to 17,530. The death toll rose to 274. The number of recovered patients increased to 6,950. There were 10,306 active cases at the end of the month. Also, there were 34,601 new cases in August, raising the total number of confirmed cases to 52,131. The death toll nearly tripled to 809. There were 32,328 active cases at the end of the month.

There were 22,453 new cases in September, raising the total number of confirmed cases to 74,584. The death toll rose to 1,191. The number of recovered patients increased to 30,952, leaving 42,441 active pandemic cases at the end of the month. In the first two weeks of October, there were 11,846 new cases and 121 additional deaths. The pandemic case's exaction rose to 86,430, and the death toll rose to 1,312. The cumulative of new case, death and recoveries were displayed in Table 1.

3.2 Measures of Model Accuracy

In this study, the time series model encompasses to forecast COVID-19 cases in the coming 60 days. The results for the measure of model accuracy for ARIMA, Linear Trend, Quadratic Linear, and S-Curve Trend, Moving Average, and Exponential model had displayed in Table 2. Look at the mean absolute percent error (MAPE), mean absolute deviation (MAD), and the mean square of deviation (MSD) values suggest that ARIMA(2,2,2) is the most accurate of all for forecasting future values as it possesses the least point for all the measures of the models.

Then, parameters are estimated for the ARIMA (2, 2, 2) model and displayed in Table 3. Then it is observed that AR (2) and MA (2) parameters have a p-value of 0.000, 0.000, 0.000, and 0.0001 respectively, indicating that the parameters are significant in the model at a 5% level of significance except for intercept.

Table 1. The descriptive result of corona virus cases, deaths, and recovery, Ethiopia, 2020

Months	March	April	May	June	July	August	September	October till (14^{th})	Total
New Cases	25	106	1041	4674	11684	34601	23237	11062	86430
New deaths	0	3	8	92	171	535	389	114	1312
Recovery	2	57	150	2221	4520	11792	12210	9213	40165

Table 2. The measure of model accuracy of time series of COVID-19 cases, Ethiopia, 2020

Models	MAPE	MAD	MSD
Exponential smooth	58.6	104.0	38375.0
Moving average (MA)	58.9	173.2	77391.4
S-Curve Trend Model	89.4	149.8	6772.1
Quadratic Trend Model	903.5	210.2	89726.1
Linear Trend Model	1164.9	218.1	90507.7
ARMA(2,2,2)	50.2	93.8	27773.0

The prediction of the new cases of COVID-19 in Ethiopia, displayed in Table 4, with a 95% confidence interval. According to the forecasted result, the number of confirmed COVID-19 new cases and deaths is slightly decreased in the coming 60 days. This decrease is s evidenced by the challenged response that invested in controlling the pandemic still in the country and awareness about the pandemic. However, the estimated forecasted values were still high, which requires more tasks to minimize the pandemic spread in the country. The main challenge of the outbreak is the reason for a few people who did not show any symptoms of the virus transmit the virus to others without knowing their test.

The result of prediction estimated maximum and minimum of Covid-19 new cases to be 672 and 387 in a single day. Also, the total confirmed cases on 13 December 2020 will be 119, 015. Specifically, in Table 4, the estimates suggest that at the end of November 2020, the number of confirmed cases of COVID-19 infections in Ethiopia will reach 465 per day. Thus, the government must implement more controlling strategies and prepare more resources.

In case of death forecast, the largest estimated is about seven deaths per day, and the lower is one per day. The total death will rise to 1418 till 14 November 2020.

Trend analysis presents meaningful statistics for confirmed COVID-19 data in Fig. 1. Fig. 1 manifests the time-series graph of the confirmed corona virus cases from 14 March 2020 to 14 October 2020. It is clear from the plot that the time series is not stationary. The decreasing trend by the time series plot and model and implies a decline with time after the peak on 21 April 2020.

The predicted future value slightly decreases in Fig. 1 in line with Table 4.

Table 3. Parameters estimates of the ARIMA (2,2,2) model of Covid-19, new cases

Type	Coefficients	SE Coeff.	t-statistic	P-value
AR(1)	-1.0184	0.1245	-8.18	0.000
AR(2)	-0.4338	0.0729	-5.95	0.000
MA(1)	0.52324	0.1185	4.49	0.000
MA(2)	0.4502	0.1317	3.49	0.001
Constant	-0.0977	0.5372	-0.18	0.856

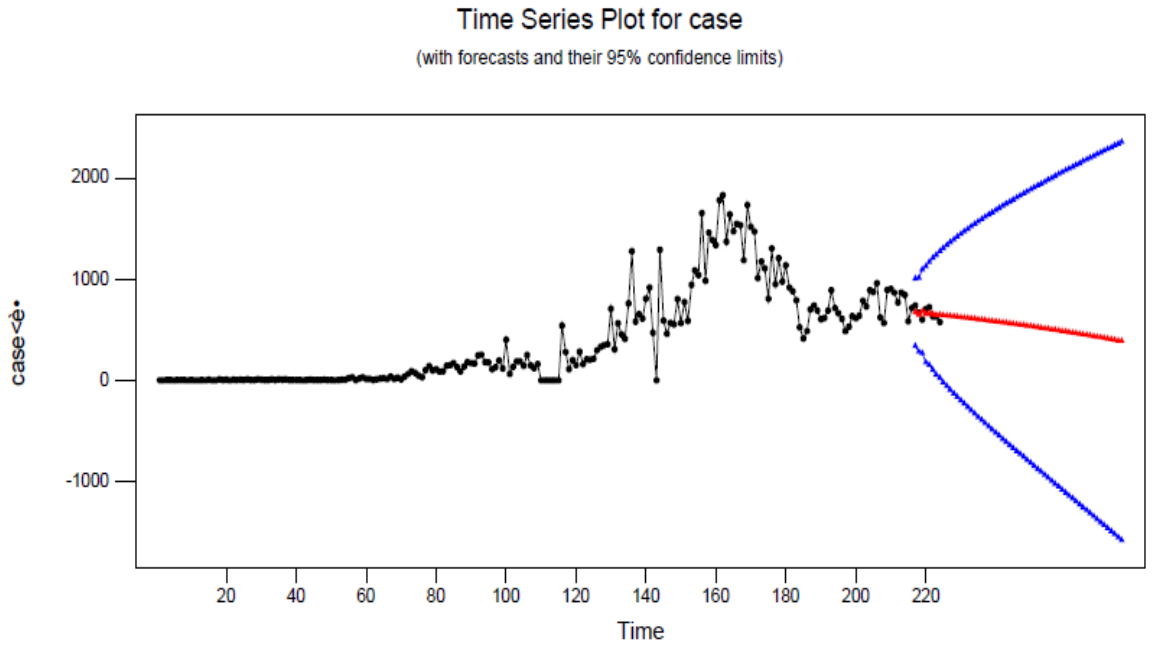

Fig. 1. Times series plot for confirmed COVID-19 infections in Ethiopia from 14 March 2020 to 14 October 2020 (Black line represents actual confirmed cases and colored lines represent case forecasts)

Table 4. The forecast point estimated values for COVID-19 cases and deaths with their lower and upper intervals for 60 days (13 March 2020 to 14 October 2020) at 95% Confidence Intervals

Date	New cases			New deaths		
	Forecast	Lower limits	Upper limits	Forecast	Lower Limits	Upper limits
15-Oct-20	672.679	339.46	1005.9	6.30097	-3.8522	16.4541
16-Oct-20	648.395	283.26	1013.53	5.32986	-5.3098	15.9695
17-Oct-20	681.68	267.35	1096.01	6.29828	-6.1866	18.7832
18-Oct-20	650.258	175.26	1125.25	5.23939	-8.6458	19.1246
19-Oct-20	659.251	151.39	1167.11	5.55621	-9.2865	20.3989
20-Oct-20	655.172	101.17	1209.18	5.24854	-10.9629	21.46
21-Oct-20	646.771	55.63	1237.91	5.01619	-12.1459	22.1783
22-Oct-20	648.235	21.61	1274.86	4.97387	-13.2738	23.2216
23-Oct-20	641.476	-21.65	1304.61	4.68399	-14.5625	23.9305
24-Oct-20	638.647	-57.35	1334.64	4.57934	-15.6136	24.7722
25-Oct-20	635.266	-93.89	1364.42	4.37581	-16.7798	25.5314
26-Oct-20	630.627	-130.42	1391.67	4.19527	-17.8631	26.2536
27-Oct-20	627.371	-164.57	1419.31	4.02918	-18.9333	26.9917
28-Oct-20	623.136	-199.33	1445.6	3.83286	-20.0083	27.674
29-Oct-20	619.17	-232.95	1471.29	3.6595	-21.044	28.363
30-Oct-20	615.229	-266.1	1496.56	3.47013	-22.0857	29.026
31-Oct-20	611.023	-299	1521.05	3.28421	-23.1075	29.676
1-Nov-20	606.949	-331.28	1545.18	3.09754	-24.1216	30.3167
2-Nov-20	602.731	-363.34	1568.8	2.90612	-25.1292	30.9414
3-Nov-20	598.478	-395.03	1591.99	2.71623	-26.1262	31.5587
4-Nov-20	594.198	-426.42	1614.82	2.52271	-27.1191	32.1645
5-Nov-20	589.836	-457.59	1637.26	2.32848	-28.1048	32.7618
6-Nov-20	585.444	-488.5	1659.39	2.13259	-29.0857	33.3509
7-Nov-20	580.993	-519.21	1681.2	1.9348	-30.0622	33.9318
8-Nov-20	576.49	-549.73	1702.71	1.7358	-31.0343	34.5059
9-Nov-20	571.941	-580.08	1723.96	1.53494	-32.0032	35.0731
10-Nov-20	567.336	-610.28	1744.95	1.33262	-32.9689	35.6341
11-Nov-20	562.683	-640.34	1765.71	1.12869	-33.9319	36.1893
12-Nov-20	557.979	-670.28	1786.24	0.92314	-34.8927	36.7389
13-Nov-20	553.223	-700.11	1806.55	0.71604	-35.8514	37.2835
14-Nov-20	548.416	-729.84	1826.67	0.50733	-36.8086	37.8232
15-Nov-20	543.559	-759.48	1846.6	0.29704	-37.7643	38.3584
16-Nov-20	538.65	-789.05	1866.35	0.08516	-38.719	38.8893
17-Nov-20	533.691	-818.55	1885.93	-0.12831	-39.6728	39.4162
18-Nov-20	528.68	-847.99	1905.35	-0.34337	-40.626	39.9393
19-Nov-20	523.619	-877.38	1924.62	-0.56001	-41.5788	40.4587
20-Nov-20	518.507	-906.73	1943.74	-0.77824	-42.5313	40.9748
21-Nov-20	513.343	-936.04	1962.72	-0.99807	-43.4837	41.4876
22-Nov-20	508.129	-965.31	1981.57	-1.21948	-44.4363	41.9974
23-Nov-20	502.864	-994.57	2000.3	-1.44247	-45.3892	42.5042
24-Nov-20	497.548	-1023.8	2018.9	-1.66706	-46.3424	43.0083
25-Nov-20	492.18	-1053.03	2037.39	-1.89323	-47.2963	43.5098
26-Nov-20	486.762	-1082.24	2055.76	-2.12099	-48.2507	44.0087
27-Nov-20	481.293	-1111.45	2074.03	-2.35034	-49.206	44.5053
28-Nov-20	475.773	-1140.66	2092.2	-2.58128	-50.1622	44.9996
29-Nov-20	470.202	-1169.87	2110.27	-2.81381	-51.1194	45.4918
30-Nov-20	464.58	-1199.09	2128.25	-3.04792	-52.0777	45.9819
1-Dec-20	458.908	-1228.32	2146.14	-3.28363	-53.0373	46.47
2-Dec-20	453.184	-1257.57	2163.94	-3.52092	-53.9981	46.9562
3-Dec-20	447.409	-1286.84	2181.65	-3.7598	-54.9603	47.4407
4-Dec-20	441.583	-1316.12	2199.29	-4.00027	-55.9239	47.9234
5-Dec-20	435.707	-1345.44	2216.85	-4.24232	-56.8891	48.4044

Date	New cases			New deaths		
	Forecast	**Lower limits**	**Upper limits**	**Forecast**	**Lower Limits**	**Upper limits**
6-Dec-20	429.779	-1374.77	2234.33	-4.48597	-57.8558	48.8839
7-Dec-20	423.8	-1404.14	2251.74	-4.7312	-58.8243	49.3619
8-Dec-20	417.771	-1433.54	2269.09	-4.97802	-59.7944	49.8384
9-Dec-20	411.69	-1462.98	2286.36	-5.22643	-60.7664	50.3135
10-Dec-20	405.559	-1492.45	2303.57	-5.47642	-61.7402	50.7873
11-Dec-20	399.376	-1521.96	2320.71	-5.72801	-62.7159	51.2598
12-Dec-20	393.143	-1551.51	2337.8	-5.98118	-63.6935	51.7311
13-Dec-20	386.858	-1581.11	2354.82	-6.23594	-64.6731	52.2012

Fig. 2, Fig. 3, and Fig. 4 displays the residual plots for confirmed COVID-19 confirmed cases in Ethiopia from 13 March 2020 to 14 October 2020. A minor and insignificant deviation of residuals showed from the straight-line on the gauss probability plot (Fig. 3). Also, it implies that the errors are somewhat near to normal due to a few outliers like the 21 April report. Thus, the normality assumption may slightly follow, but the residual histogram has followed the assumption of normality (Fig. 4). The graph between residuals and the fitted values displays a little dispersion at very early times, and about 19 % of the new case values are zero (Fig. 2). It implies that the assumption of constant variance is also satisfied by the model on the time data if smaller (zero) data values dropped.

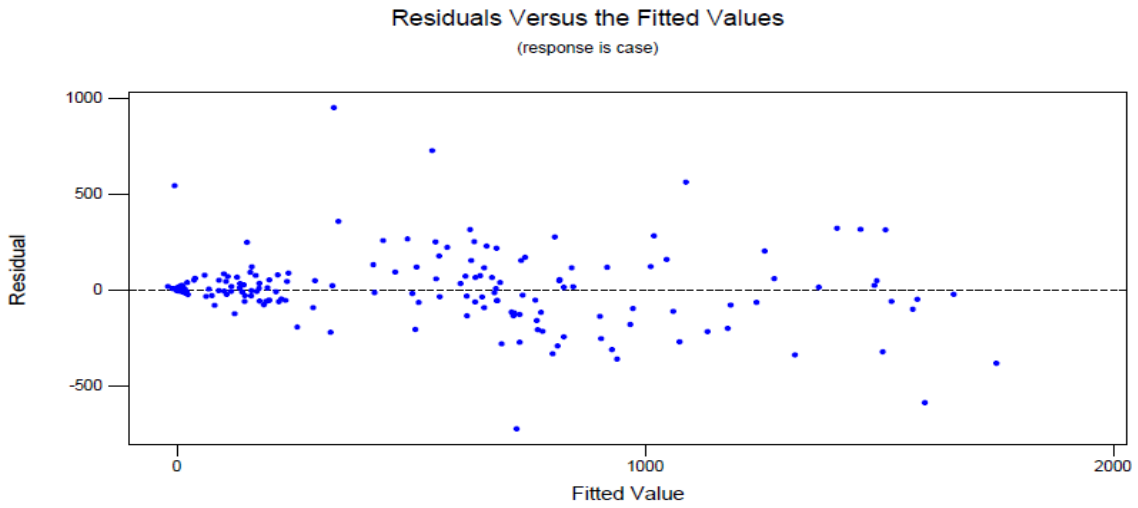

Fig. 2. Residual verses fitted values of the Corona Virus in Ethiopia, 2020

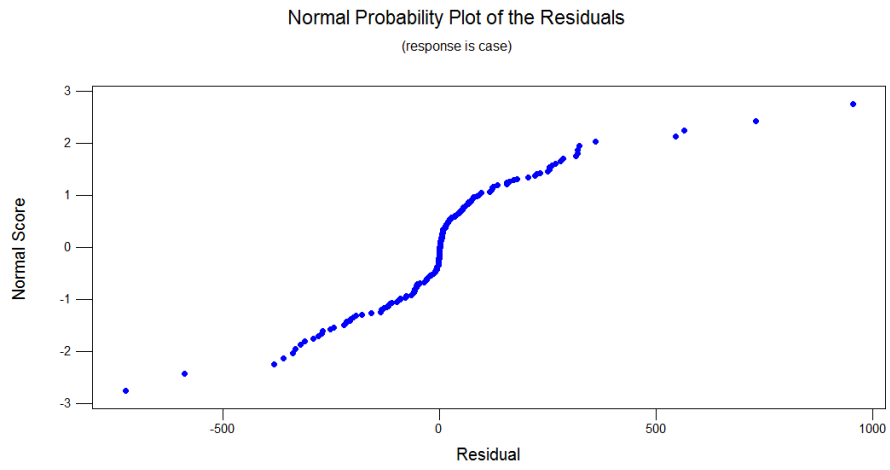

Fig. 3. Normal probability plot of the residual of the Corona Virus in Ethiopia, 2020

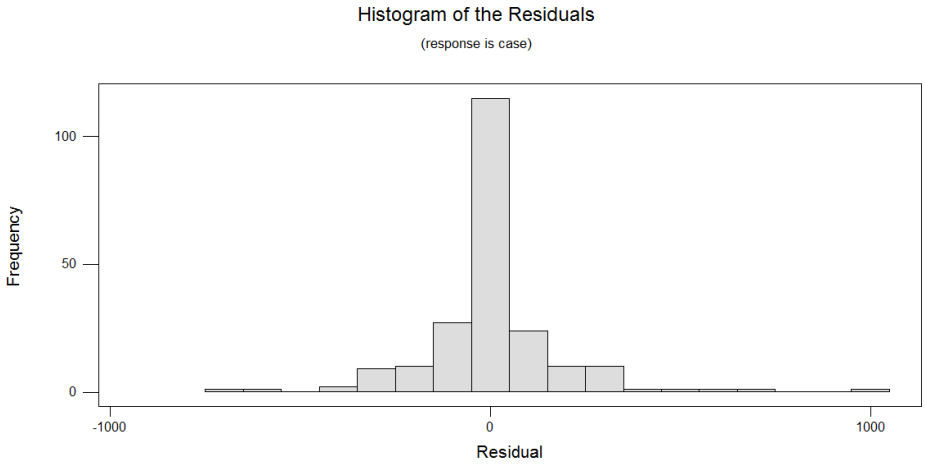

Fig. 4. Histogram of the residual graph of the Corona Virus in Ethiopia, 2020

4. DISCUSSION

The main objective of this study was to predict future values of the COVID-19 cases in Ethiopia based on recent reports. It has the purpose to create a reliable and suitable predictive model that can help governments and other stakeholders to control the further spread of COVID-19.

ARIMA models are the statistical technique that gives a decent prediction and has been widely applied for the trend of infectious disease in quick time [2,9,10,12]. ARIMA models assume a linear correlation between the time-series values and attempt to exploit these linear dependencies in observations, in order to extract local patterns, while removing high-frequency noise from the data [2]. It offers a high level of interpretability and performed in an automated way to maximize prediction accuracy [2,10].

The time series model and plot suggested that there was a slight decline in the number of a new case of future times in Ethiopia. It was forecasted that by firs two weeks of December 2020, the number of confirmed cases in the country reach 119, 015. Inline at the end of October, cumulative infections across Ethiopia predicted to reach 56,610 when looked at an average [9], while the actual value till 19 October only was 89,137 cases and 1352 deaths [5]. This means that the number of corona virus-positive people in Ethiopia may lift up more than predicted by [9]. However, in this study, the cumulative number of new cases at the end of October will reach 97502. Thus, this study was forecasted more accurate value than the other scholars [9].

The distribution of pandemic in Ethiopia with in first three months was increasing [9]. The trends of the pandemic in the USA and India were increasing from 12 July 2020 to 11 September 2020 [10,13]. The countries are now the first and second highly confirmed pandemic cases. The Indian confirmed COVID-19 case was forecasted with ARIMA and suggested to implement lockdown [9]. However, the protective mechanisms suggested were not implemented now the threat of a pandemic is uncontrollable in India. According to the WHO report, Ethiopia was 4th in the number of confirmed COVID-19 cases and even more than China [5]. It is assumed that the worst-case scenario happens if and only if the standard WHO disease preventive and control measures are not taken [9]. Hence, in this study slight decline was observed on Ethiopian day to day report (Table 4 and Fig. 1).

Similar to other scholars, studies have been conducted to predict the prevalence of COVID-19 cases using the ARIMA model [9,10,11,12]. Consistent with this study they found that ARIMA models appropriate for forecasting the prevalence of Covid-19 [13]. ARIMA model Forecasting of the pandemic outbreak in India and shows that the infected cases in India in the most critical case [10]. Since the same model used in this study, they show that the ARIMA model was effectively able to predict future coronavirus cases. Thus, the country must implement controlling mechanisms and develop even more policies to control the pandemic to stop it.

5. CONCLUSION

Despite, the COVID-19 pandemic maybe show a small decrease in Ethiopia if the Government of Ethiopia ceased controlling mechanisms it may relapse again and affects the country more again. Therefore, the study suggested that proactive and

control mechanisms will implement without ceasing. Since, the model is an effort to predict the future forecast of COVID-19 distribution, based on the present data, so that the concerned organizations can develop policies, and can implement it from now.

CONSENT

It is not applicable.

ETHICAL CLEARANCE

The ethical clearance of the study was taken from Mizan-Tepi University, Department of Statistics. Since the secondary data taken from daily report of Etiopian federal ministry of health it never hart any individual in the study.

COMPETING INTERESTS

Author has declared that no competing interests exist.

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