Analysis of Confirmed Cases of Corona Virus Diseases (COVID-19) in Nepal

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ABSTRACT

An outbreak of COVID-19 pandemic disease, caused by a novel coronavirus SARS-coV-2, has posed a serious threat to global human health and economic activities. Nepal is also severely affected by this viral disease. The first case of COVID-19 patient was detected in Nepal on January 23, 2020. Since then, a total of 976,105 cases were reported as COVID-19 infected and the recovered cases were 953,430 with a recovery rate of 97.7 per cent with 11,928 deaths and a case fatality rate of 1.2 per cent until February 22, 2022. It would help the government to manage this crisis if the proper mechanism to predict COVID-19 cases has been developed. To combat COVID-19, the government of Nepal has taken various steps viz. diagnosis of the suspected cases, quarantine for people coming from other countries and isolation of the infected patients, lockdown, closure of the international boarder, increase public awareness, enforced social distancing, in the first phase, the addition of ICU beds, ventilator, oxygen concentrator and oxygen plant in a different hospital in the second phase and then vaccination of the target population, booster dose after the sixth month of a full dose of vaccination. This study aims to analyze the pattern of COVID-19 cases and death cases and forecast their values based on the data from January 23, 2020, to February 22, 2022, obtained from the website World Bank based on the ARMA model. This study indicates that the patients of COVID-19 are crossed three waves in Nepal, in the first wave the maximum number of cases was 4187, in second-wave the maximum number of cases was 9226 due to delta variant and in the third wave the maximum number of cases were 10052 is due to omicron. The forecasted value for March 18, 2022 for total cases is 984,595 with UCL values 1,056,143 and LCL values 913,047. Similarly, the forecasted value for new cases is 146 with UCL values 4,222 and LCL values 0 and for new death, the forecasted value is 4 with UCL values 78 and LCL values 0. These forecasted values indicate that the impact of Covid-19 is decreased rapidly due to vaccinations.

Keywords: *ARMA model, COVID-19, SARS-coV-2, Nepal*

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INTRODUCTION

The novel coronavirus COVID-19 (SARS-CoV-2) was first reported on 31st December 2019 in Wuhan city of China (Lu, Stratton, & Tang, 2020). To date, most COVID-19 infected patients have developed mild symptoms of dry cough, sore throat, and fever. However, some have developed serious problems like organ failure, septic shock, pulmonary oedema, pneumonia, and Acute Respiratory Distress Syndrome (ARDS). Intensive care unit patients were also suffering from dyspnoea, dizziness, abdominal pain and anorexia (Wang, et al., 2020).

World Health Organization declared the outbreak of COVID-19 to be a Public Health Emergency of International Concern indicating a high risk to countries with vulnerable health systems on 30th January 2020. The Severe Acute Respiratory Syndrome Coronavirus 2(SARS-CoV-2) formerly known to be COVID-19 has emerged as a zoonotic agent which is appeared in December 2019 and causes Novel COVID-19 (Bonilla-Aldana, Dharma, & &Rodriguez-Morales, 2020). It has resulted in a pathogen that leads to severe and critical conditions that require intensive care in hospitals in most cases (Zhu, et al., 2020; Chan, et al., 2020; Huang, et al., 2020; Bastola, et al., 2020). The spread of COVID-19 may be interrupted by early detection, isolation, prompt treatment and a robust system to trace contacts (World Health Organization, 2020).

Viruses mutate regularly such that few of them are significant and others are insignificant, and COVID-19 has undergone thousands of mutations since it first emerged (Duong, 2021); among them, a very small minority is likely to be significant and change the virus meaningfully (Wise, 2020). There are thousands of variants of COVID-19, but as of Nov 2021, there are only 4 variants of concern (European Centre for Disease Prevention and Control, 2022). The beta variant was first detected in South Africa, the Gamma variant was first detected in Brazil, the Delta variant was first detected in India, and Omicron was first detected in South Africa and Botswana. A variant of concern is a strain of covid-19 which is more infectious and infected those who are vaccinated or previously infected, causes severe disease, evade diagnostic test, or resist antiviral treatment.

On 13th January 2020, a Nepalese student at Wuhan University of Technology Wuhan, China, with no history of co-morbidities, returned to Nepal was the first patient of COVID-19 in Nepal detected on 23 January 2020 and is announced on 24 January 2020. Since the first case was detected, the government of Nepal has been working on minimizing the spread and impact of the viral disease, (Government of Nepal; Ministry of Health and Population, 2020).

The initial response was the disseminate information via Television, Radio, F.M. including the caller tunes on cell phones, to train the frontline healthcare workers, and to set up a domestic testing system by establishing central and local testing laboratories. In addition, the government established a COVID-19 crisis management system and focus on setting up temporary hospitals, quarantine, isolation and intensive care unit beds in each province. After the first confirmed case, 23rd march one more case is confirmed and increased gradually and local transmission was detected on April 4, 2020. On September 30 2020 (week no. 40), all seven provinces and 77 districts have reported one or more cases since the beginning of the COVID-19 pandemic in Nepal (WHO, 2020). Nepal declared a nationwide lockdown from 24th March to 21st July 2020, banning domestic and international travel, and closure international borders and services in the first stage except for essential services, which was later eased on 11 June 2020. The total confirmed cases were in a single-digit up to 11 April 2020. On 12 April total confirmed cases are 12 and were more than 8 fold greater (101 cases) on 7 May 2020, within 25 days although lockdown was implemented from March 24. The confirmed cases crossed 1000 (1042 cases) on May 28, 2020. It crossed 10,000 (ie.10099) confirmed cases on 23 Jun 2020.

As of Feb 22, 2022, a total of 976,105 COVID-19 cases were confirmed, out of the 97.7% (953,430) of cases have been recovered, 10,747 of the cases are active, and 11,928 deaths. All 7 provinces in the country are now experiencing community transmission. At a national level, the second wave of cases between July 2020 and February 2021 was followed by the third wave from the middle of March 2021 (WHO, 2021).

The first death due to COVID-19 was recorded on 16 May 2020 and is increased rapidly became 23 on 21 June 2020. Surprisingly, in the majority of the deaths, people died outside of a hospital, and COVID-19 was confirmed after death crossed 100 (ie.102) on 15 August, crossed 1000 (ie.1004) on November 3, and 11,590 deaths up to Dec 29, 2021.

The sample of the first COVID-19 suspected case was sent to Hongkong, as Nepal didn't have a reagent for a test. The National Public Health Laboratory started testing (RT-PCR) the virus on 27 January 2020. At present, 104 laboratories can test the virus. There are 9 laboratories in province 1, 10 in province 2, 56 in Bagmati, 6 in Gandaki, 12 in Lumbini, 4 in Karnali, and 7 in Sudur-Paschim province. Up to Feb 22, 2021, total test of PCR is 5,391,603 and Antigen test is 1,044,733. The total positive cases from the PCR test is 976,105 and from the Antigen test is 138,915 with a recovery rate of 97.7 per cent and case fatality rate of 1.2 per cent. The total number of people vaccinated for at least one dose was 21412986 (73.4%) and full-dose was 17786133 (60.9%). The main objective of this study is to identify the trends of

confirmed cases and deaths. And forecast the future trend based on the ARIMA model.

DATA AND METHODS

Nationwide data was collected by the Ministry of Population and Health-related to COVID-19 was obtained from Jan 24, 2020, to Feb 22, 2022, from the official website of MoPH; covid19.moph.gov.np, WHO Office for Nepal, reports, guidelines, national and international government documents, WHO situational reports, and news were analyzed. Box and Jenkins (1971) developed a method that combined autoregressive and moving average models called autoregressive moving average (ARMA) models and is best for univariate time series modelling. The autoregressive model assumed that the future values dependent on a linear combination of past observations and a random error. Mathematically AR(p) model can be expressed as;

$$Y_t = c + \phi_1 y_{t-1} + \phi_2 Y_{t-2} + \phi_3 y_{t-3} + \phi_4 y_{t-4} + \ldots + \phi_p y_{t-p} + \varepsilon_t$$

Where Yt and ε_t are the actual value and the error at time t, ϕ_i (i = 1,2,3,4 ….) are model parameters and c is a constant and p is the order of the model.

The moving average MA(q) model assumed that past errors as explanatory variables. The MA(q) model can be expressed as;

$$Y_t = \mu + \theta_1 \varepsilon_{t-1} + \theta_2 \varepsilon_{t-2} + \theta_3 \varepsilon_{t-3} + \theta_4 \varepsilon_{t-4} + \ldots + \theta_p \varepsilon_{t-q} + \varepsilon_t$$

Where μ is the average value of the series, $\theta j (j = 1,2,3 … q)$ are model parameters and q is the order of the model. Mathematically an ARMA (p,q) model can be expressed as;

$$Y_t = c + \mu + \phi_1 y_{t-1} + \phi_{2yt-2} + \phi_3 y_{t-3} + \phi_4 y_{t-4} + \ldots + \phi_p y_{t-p} + \theta_1 \varepsilon_{t-1} + \theta_2 \varepsilon_{t-2} + \theta_3 \varepsilon_{t-3} + \theta_4 \varepsilon_{t-4} + \ldots + \theta_p \varepsilon_{t-q} + \varepsilon_t$$

The autoregressive and moving average can be used for a univariate stationary time series only. The stationarity of the time series is tested by the unit root test. The stationarity is obtained in time-series data by differentiating it d (1,2,3,…) times. Such a time series model is called an ARIMA (p,d,q) model.

The ARIMA model has seen widespread usage in the study of infectious diseases for several time-series events. These include leptospirosis and its relationship with rainfall and temperature (Chadsuthi, Modchang, Lenbury, Iamsirithaworn, & Triampo, 2012) and the relationship of suicide cases with changes in national alcohol policies (Pridemore & Snowden, 2009) among others. Time series modelling of infectious diseases specially COVID-19 has been reported by several researchers (Ghosal, 2020;Tiwari, 2020; Bhola, Venkateswaran, & Koul, 2020). The automatic ARMA model is used based on the given data by using SPSS

version 25 which selects the ARMA (3,1,6) model for the best prediction of the next month.

RESULTS AND DISCUSSION

As of Feb 22, 2022, Nepal confirmed 976,105 COVID-19 cases *11,928 i*ncluding deaths. The total recovery rate was 97.7% with a case fatality rate of 1.2%. Figure1 shows the distribution of new cases each day from Jan 23 2020, to Feb 22 2022, indicating that Nepal has a maximum of 5,743 cases in the first wave on 21st October 2020, due to the celebration of major festivals; the maximum number of new cases in the second wave was 9,317 on May 11, 2021, due to reopening of school, college, public precaution lapses to dangerous low with a decline of some cases, semblance of normal life resume with large political rallies, marriage ceremony festival celebration with little to no social distancing; and the maximum number of daily cases in the third wave was 10,052 on Jan 20 2022, due to Omicron variant and then decrease gradually and becomes 299 on Feb 22 2022. WHO standard published in May 2020, indicated that the epidemic situation in a country is under control if a positive rate of COVID-19 less than 5%. The positive rate of COVID-19 in Nepal is 16.3% which is very high than the standard positive rate. The task of epidemic prevention and control is still arduous in Nepal. Figure 1 also indicated the predicted values based on the automatic ARIMA model (3,1,6) and forecast for the next three months which is given in table 1.

Figure 1

Number of New Cases from January 25, 2020, to Feb 2022 and Forecast New Cases up to Mach 20, 2022
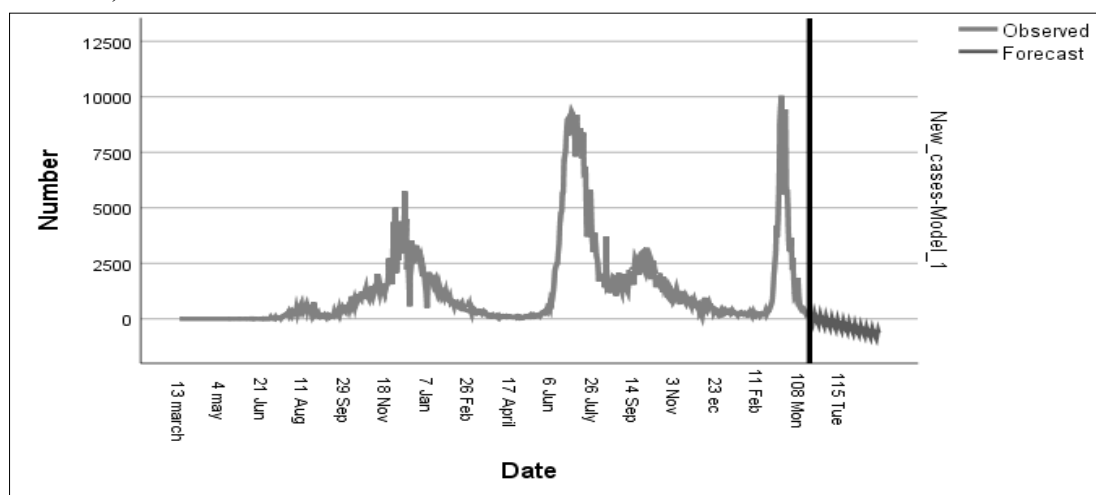
Table 1 indicates that the forecasted value of new cases is within the three digits indicating the effect of massive vaccination campaigns against COVID-19 above 12 years old and booster doses for adults.

Table 1

Forecasted of New Cases from February 22 2022 to March 20 2022

Model		Feb 23	24	25	26	27	28	28	March 1	2	3	4	5	6	7
New_cases-Model_1	Forecast	504	413	232	72	35	111	248	340	324	218	104	65	125	234
	UCL	1386	1463	1475	1490	1630	1869	2186	2464	2619	2655	2656	2719	2884	3110
	LCL	-379	-637	-1011	-1345	-1560	-1646	-1690	-1784	-1972	-2220	-2448	-2589	-2634	-2641

8	9	9	10	11	12	13	14	15	786	16	17	18	19	20
311	302	218	124	90	136	224	288	283	217	141	111	146	216	270
3311	3421	3443	3439	3487	3617	3797	3959	4051	4072	4073	4114	4222	4371	4507
-2688	-2818	-3007	-3190	-3307	-3345	-3349	-3383	-3484	-3638	-3791	-3893	-3931	-3938	-3968

Figure 2 indicates that the first case of COVID -19 was confirmed on 23rd January followed by the second case on March 23, 2020. Nepal implemented Lockdown from 24th march to 21st July 2020, banning domestic and international travels, closure borders and services except for emergency services in the first stage, which was later eased on 11 June 2020. On 11th June, the total no of cases became 4,614 with total deaths of 15. The number of the case forth folded (16,719) within one month July 11, 2020. Further, the number of cases increased three-fold (51,919) on September 11 2020. The number of cases exceeds 100,000 on 9th October 2020 and doubled (202,319) on 11th November 2020, and steady up to 25th April 2021 to become 300,119, becomes 646,367 on 5th July 2021, and 976,105 COVID-19 cases up to Feb 22, 2022. Figure 2 indicates that the number of total cases is now increased slowly due to a rapid vaccination campaign against COVID- 19 above 12 years old and providing the booster dose for adults who are vaccinated before 6 months. The forecasted value for the next 30 days is given in Table 2.

Figure 2

Total Cases of COVID-19 from January 23 2020, Feb 22 2022, and the Forecasted Cases from February 23 to March 20
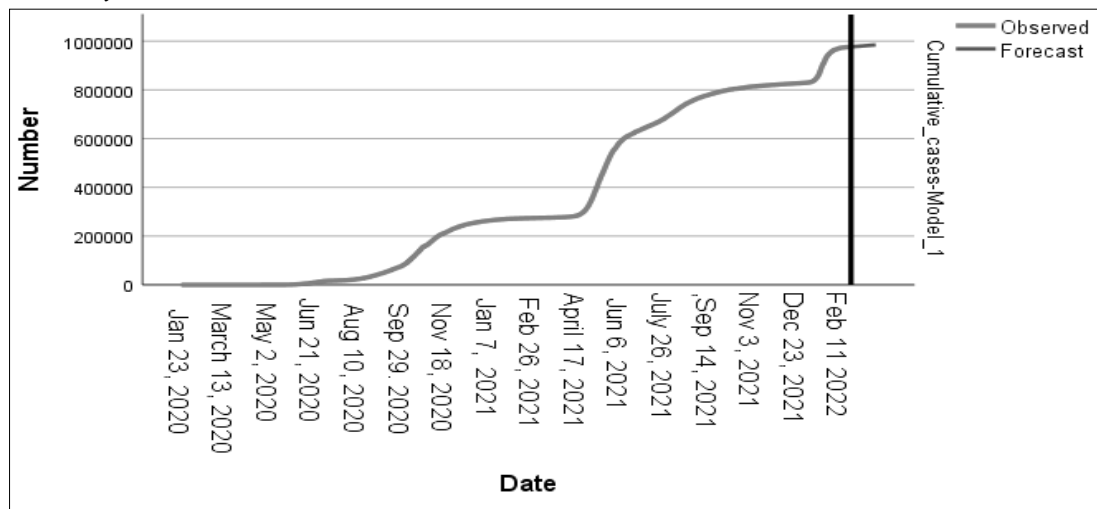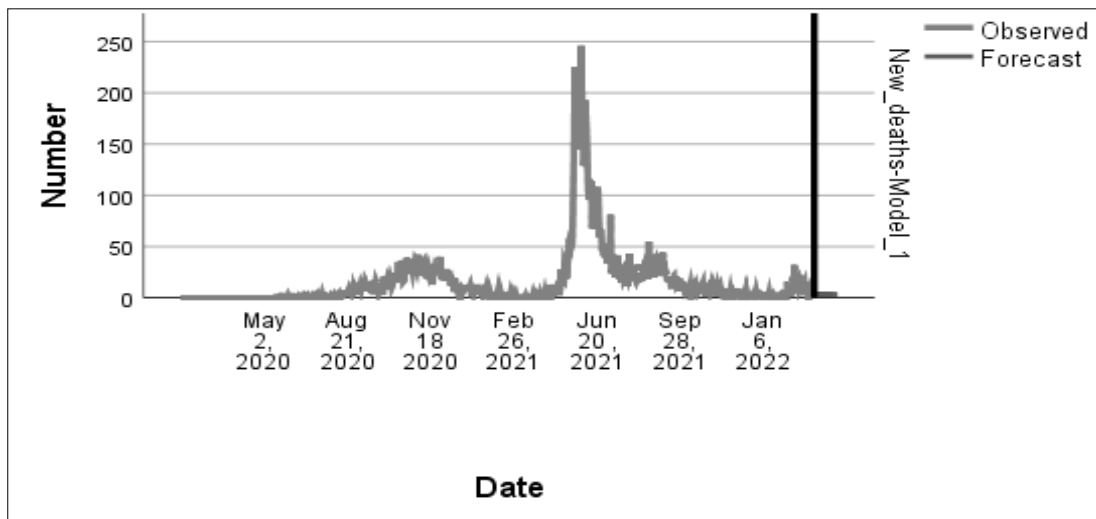

Table 2

Total Forecasted Cases from February 22, 2022, to March 18, 2022

Model		Feb 23	24	25	26	26	27	28	28	March 1	2	2	3	4	4	5
Cumulative_cases-Model_1	Forecast	976391	976684	976977	977270	977563	977856	978149	978442	978735	979028	979321	979614	979907	980200	980493
	UCL	977316	978523	979970	981602	983394	985329	987395	989584	991887	994298	996812	999424	1E+6	1E+6	1E+6
	LCL	975467	974845	973985	972939	971733	970383	968903	967301	965584	963759	961831	959805	957684	955473	953174

6	7	8	9	10	11	12	13	14	15	16	17	18
981079	981372	981665	981958	982251	982544	982837	983130	983423	983716	984009	984302	984595
1E+6	1E+6	1E+6	1E+6	1E+6	1E+6	1E+6	1E+6	1E+6	1E+6	1E+6	1E+6	1E+6
948325	945780	943157	940459	937687	934844	931929	928947	925896	922780	919599	916354	913047

The number of deaths due to COVID-19 is shown in Figure 4. The first COVID-19 death case was on May 16 2020, after five months of COVID-19 first case, and then gradually increased and reached 102 on 15th August 2020. Due to a lack of proper health facilities, the number of death increased rapidly and crossed 1000 (ie. 1004) on November 3, 2020. The number of deaths crossed 5000 (5001) on May 16, 2021, within 1 year, and 9,248 on July 5 2021. Figure 3 represents the number of new deaths every day and the pattern of deaths in Nepal. Table 3 represents the forecasted value up to March 20, 2022.

Figure 3

Number of New Deaths from 16th May 2020 to 22nd February 2022

The new number of deaths in Nepal was shown in figure 3. The first death case was recorded on 16th May 2020 and then new deaths become stable up to (below 10) 20th August 2020. The death cases increased in double digits up to 20th December 2020 after that the new death cases decline gradually up to 23rd February 2021. The forecasted value for the next months is given in Table 3.

Table 3

Forecasted New Death Cases from February 22 2022 to March 18, 2022

		Forecast										
Model		Feb23	24	25	26	27	28	March 1	2	3	4	5
New_deaths-Model_1	Forecast	4	3	3	3	3	3	4	3	4	4	4
	UCL	21	24	27	28	31	33	37	40	44	46	49
	LCL	-14	-18	-20	-22	-25	-27	-30	-34	-36	-39	-42

6	7	8	9	10	11	12	13	14	15	16	17	18	19
4	4	3	4	3	4	4	4	4	4	4	4	4	4
51	54	56	59	61	63	65	67	69	71	72	74	76	78
-44	-47	-49	-52	-54	-56	-58	-60	-62	-63	-65	-67	-69	-70

Table 4

Descriptive Statistics of New Cases, Cumulative Cases and New Deaths from Jan 23 2020 to Feb 22 2022

Date_reported	New_cases	Cumulative_cases	New_deaths
1st Qu.:2020-07-31	1st Qu.: 136.8	1st Qu.: 19850	1st Qu.: 0.00

Median :2021-02-06	Median : 489.0	Median :271866	Median : 5.00
Mean :2021-02-06	Mean : 1281.0	Mean :363434	Mean : 15.65
3rd Qu. : 2021-08-15	3rd Qu.: 1611.0	3rd Qu.:734197	3rd Qu.: 18.75
Max. :2022-02-22	Max. :10052.0	Max. :976105	Max. : 246.00

The descriptive statistics indicated that the data are positively Skewed and the average number of new cases was 1,281 with a maximum value of 10,052. The average number of cumulative cases was 363,434 with a total number of cases were 976,105 till Feb 22, 2022. The average number of new Death is 15.65 with a maximum number of new death being 246.

The statistical analysis of data is being represented with the ARIMA model the powerful tool in statistics that helps in analysing the results obtained from the graphs plotted above. Using the ARIMA model the forecasted values for march 18, 2022 for total cases is 984,595 with UCL values of 1,056,143 and LCL values of 913,047. Similarly, the forecasted value for new cases is 146 with UCL 4,222 and LCL 0 and for new death, the forecasted value is 4 with UCL 78 and LCL 0. This forecasted value indicates that the impact of Covid-19 is decreased rapidly due to vaccinations.

CONCLUSION

The ARIMA model shows the forecasted value for Nepal for the next one month is helpful for policy maker to plan their action against COVID -19 in the coming days.

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