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Forecasting analysis of COVID-19 cases in eastern Visayas, Philippines

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Abstract
The disease caused by the novel coronavirus was named by the World Health Organization as COVID-19. COVID-19 has a basic reproduction number of 2 – 2.5, indicating that two to three people will contract the virus from a single patient. The first case in the Philippines was reported on January 30, 2020 when a Chinese woman arrived via Hong Kong from Wuhan, China. Her male companion died a few days later, the first known death outside of China. The Eastern Visayas region of the Philippines also felt the impact of the virus and had community-level transmissions. In this study, the researchers used ARIMA to forecast the COVID-19 cases of the provinces/cities in the region, namely, Biliran, Eastern Samar, Northern Samar, Samar, Leyte, Southern Leyte, Tacloban City, and Ormoc City, from September 5, 2021 to October 30, 2021. The dataset for this study where the official COVID-19 cases dataset from March 1, 2020 to October 30, 2020 provided by the Regional Epidemiology & Surveillance Unit of the Department of Health (DOH) – Eastern Visayas Center for Health and Development. Based on the results, it was found that all provinces/cities will have different developments in their COVID-19 cases. The results can be used in making strategic decisions in terms of planning, managing, procuring facilities, and other relevant mechanisms to address COVID-19 and similar healthcare operations in time of the pandemic.

Keywords: SARS-Cov-2, COVID-19, time series, forecasting, ARIMA, Eastern Visayas

Introduction
SARS-Cov-2 is a novel coronavirus strain that has not previously been associated with human infection. COVID-19 is the name given to the disease caused by SARS-Cov-2. To prevent inaccuracy and stigma, the disease's name was chosen in accordance with best practices, and did not make reference to a geographic location, an animal, an individual, or a group of people. The World Health Organization declared it a Public Health Emergency of International Concern on January 30, 2020 [1].
The virus is highly contagious and can cause human- to-human transmission [2]. It can be transmitted among humans via close contact with an infected individual that produces respiratory droplets by coughing or sneezing within an estimated 1-meter radius [3]. Additionally, the virus can be transmitted to humans when they contact a contaminated surface and then touch their eyes, nose, or mouth [4]. Though cases are rare, the virus can be transmitted via aerosol in a relatively confined space, with a high level of aerosol exposure over a lengthy period of time [5]. COVID-19 has a basic reproduction number of 2–2.5, indicating that two to three people will contract the virus from a single patient. The most effective virus detection method is through a Reverse Transcription Polymerase Chain Reaction (RT-PCR) test according to WHO [4].
The incubation period for exposure to experiencing symptoms is normally 7-14 days, with the shortest being one day and the longest being up to 20 days. According to laboratory data, infected individuals appear to be most infectious just before they develop symptoms (specifically, two days before) and during the early stages of their illness. Individuals who develop a severe disease may remain infectious for an extended period of time. Whereas an individual who does not exhibit symptoms can transmit the virus to others, the frequency with which this occurs is unknown, and additional research in this area is necessary [4].

By March 7, 2020, the global total of confirmed COVID-19 cases had surpassed 100,000. The WHO released a statement urging for immediate action to stop, confine, control, delay, and reduce the virus' impact at every opportunity [6].

The rapid growth of cases outside of China caused the World Health Organization's Director-General to declare the epidemic a pandemic on March 11, 2020. At the time, almost 118,000 cases had been reported in 114 countries, with 4,291 deaths [7]. The global case count surpassed 1 million on April 4, 2020, with a death toll of more than 50,000. This case count was alarming, since the recorded cases increased more than tenfold in less than a month. Then on April 9, 2020, the World Health Organization marked 100 days since the first cases of "pneumonia with an unknown cause" were reported [8].

The first case in the Philippines was reported on January 30, 2020 when a Chinese woman arrived via Hong Kong from Wuhan, China. Her male companion died a few days later, the first known death outside of China [9, 10, 1]. By March 7, the first local transmission was confirmed [9, 8]. Then on March 8, 2020, President Rodrigo R. Duterte issued Proclamation 922, proclaiming a state of national emergency in response to the threat of COVID-19, based on the recommendation of the Health Secretary [21]. The Philippines became one of the countries most severely impacted in the Southeast Asia and the Western Pacific Region. The effects of COVID-19 was alarming because of the high number of doctors, nurses, and other medical professionals who contract COVID-19 and die as a result [12, 13]. By September 4, 2021, DOH Philippines recorded 20,741 new cases bringing the cumulative confirmed cases to 2,061,084 with 1,869,376 recoveries, and 34,062 deaths.

The Philippines' public health system, like that of other countries worldwide, was unprepared for and overburdened by COVID-19. The Philippines, as a developing country, has limited medical facilities for its 109 million residents based on the latest Census of the Philippine Statistics Authority (May 1, 2020) [14]. Suffice to say, it was inevitable that the country would face major problems if the virus reaches its soil.

The Eastern Visayas region of the Philippines also felt the impact of the virus. As of September 4, 2021, DOH Eastern Visayas recorded a cumulative total of 42,287 COVID-19 cases in the region. It is therefore important for the health experts and local governments in the region, to be provided with a comprehensive information about the virus, and forecast the movement of the cases whether it will increase or decrease in future, to be able to plan, manage, procure facilities, and other relevant mechanisms to address COVID-19 and similar healthcare operations in time of pandemic. As a contribution to the community, the researchers decided an analysis of the COVID-19 cases in Eastern Visayas.

The data for this study where the official COVID-19 cases dataset from March 1, 2020 to September 4, 2021 provided by the Regional Epidemiology & Surveillance Unit of Department of Health (DOH) – Eastern Visayas Center for Health and Development. The cases were grouped by province/city, namely, Biliran, Eastern Samar, Northern Samar, Samar, Leyte, Southern Leyte, Tacloban City, and Ormoc City. Autoregressive Integrated Moving Average (ARIMA) modelling was used to forecast the weekly cases from September 5, 2021 to October 30, 2021.

Methodology

Study Design and Data

The research design appropriate for this study is a quantitative, correlational, and predictive research design which utilizes time series analysis and forecasting. The analysis is based on the official COVID-19 cases dataset provided by the Regional Epidemiology & Surveillance Unit of Department of Health (DOH) – Eastern Visayas Center for Health and Development. The data includes the weekly case count from March 1, 2020 to September 4, 2021 for the different provinces/cities in Eastern Visayas.

Study Locale

Eastern Visayas is an administrative region of the Philippines. It consists of three main islands: Samar, Leyte, and Biliran. The region has six provinces, one highly urbanized city, and one independent city. This study was conducted using the secondary data on the COVID-19 cases of these provinces and cities, namely, Biliran, Eastern Samar, Northern Samar, Samar, Leyte, Southern Leyte, Tacloban City, and Ormoc City.

Aside from being the researchers' home region, Eastern Visayas was chosen as the locale because of the recent surge of COVID-19 cases. The region's lack of facilities and preparation for outbreaks caused major problems in the locality.

Data Gathering Procedure

The weekly COVID-19 positive cases by province/city in Eastern Visayas from March 1, 2020 to September 4, 2021 and the morbidity week calendar for years 2020 and 2021 were collected from the Regional Epidemiology & Surveillance Unit of DOH – Eastern Visayas Center for Health and Development. The

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Statistical Treatment

The weekly COVID-19 positive cases data were categorized and tabulated by province/city, namely, Biliran, Eastern Samar, Northern Samar, Samar, Leyte, Southern Leyte, Tacloban City, and Ormoc City.

The Autoregressive Integrated Moving Average (ARIMA) Models were used to forecast the cases for the eight weeks after the Morbidity Week 35 of 2021. The Augmented Dickey-Fuller (ADF) Test was also used to determine stationarity, followed by the corrected Akaike Information Criterion (AICc), and Bayesian Information Criterion (BIC) to select the best model possible. The ADF test was performed at both 1% and 5%. The forecasting done via ARIMA models was aided with SPSS, while the test for stationarity and model selection using the information criteria was done using R programming.

ARIMA (p, d, q) Model

ARIMA is an abbreviation for auto-regressive, integrated, moving average. The auto-regressive element, *p*, represents the lingering impacts of the scores that came before it. The integrated element, *d*, represents patterns in the data, and the moving average element, *q*, represents the residual effects of preceding random shocks. This statistical model uses time series data to better understand the dataset, predict future trends, and predict future values based on past values. The researchers used ARIMA modeling since it is one of the simpler and more flexible, yet powerful method for making time series forecasts.

Augmented Dickey-Fuller (ADF) Test

The ADF test compares the null hypothesis of a time series *yt* being $I(1)$ against the alternative hypothesis of being $I(0)$, assuming that the data dynamics have an Autoregressive Moving Average (ARMA) structure. The ADF test is based on estimating the test regression

$$y_t = \beta' D_t + \phi y_{t-1} + \sum_{j=1}^{p} \psi_j \Delta y_{t-j} + \varepsilon_t \quad (1)$$

where Dt is a vector of deterministic terms (constant, Fuller (ADF) test was the first step the researchers trend etc.). The p lagged difference terms, Δy_{t-j}, are used to approximate the ARMA structure of the errors, and the value of *p* is chosen to ensure that the error ε_t is serially uncorrelated [15]. Essentially, the ADF test is used to determine whether a time series is stationary or not, and it finds the number of differencing necessary to make a time series stationary.

Corrected Akaike Information Criterion (AICc)

The AICc is a corrected Akaike Information Criterion (AIC) used for smaller sample sizes and when $n/d < 40$ [16]. In model selection, Ref. [17] propose the following criterion:

$$AICc = 2d - 2\ell_n + \frac{2d(d+1)}{n-d-1} \quad (2)$$

where d is the dimension of the model and n is the sample size. The AICc is a method for determining how well a model fits the data from which it was derived. In other words, the AICc is used to determine which of several candidate models is most likely to be the best fit for a given dataset.

Bayesian Information Criterion (BIC)

Another common approach for model selection is the BIC given by:

$$BIC = d \log n - 2\lambda\, n, \quad (3)$$

where again d denotes the dimension of the model. In the Bayesian setting, there is a prior $\pi(m)$ over all potential models, and a prior over parameters $p(\theta|m)$ within each model. The BIC is a Bayesian criterion, which means that the model is selected based on the posterior distribution of each model m [18]. Although it can be proportionate, the quantity calculated from BIC differs from that calculated by AIC. Unlike the AIC, the BIC penalizes the model for its complexity, which means that more complex models get a worse (higher) score and are less likely to be chosen. Importantly, the derivation of BIC within the Bayesian probability framework implies that when a selection of potential models includes a true model for the dataset, the likelihood that BIC will select the true model increases with the size of the dataset. This cannot be said for the AIC score.

Results and Discussion

The weekly COVID-19 cases in the different provinces/ cities of Eastern Visayas had shown trends in the time period. In addition, the presence of a lot of irregular variations have caused some time series to become non-stationary.

In order to conduct an ARIMA modeling procedure, stationarity is needed. Stationarity refers to the time series property wherein the mean, variance and autocorrelation structure do not change over time. Determining the stationarity of the observations/cases of the provinces/cities by utilizing the Augmented-Dickey Fuller (ADF) test was the first step the researchers conducted in order to construct an ARIMA model.

Test for Stationarity

The ADF test does not directly test for stationarity but rather, it tests for the presence of Unit Root. Unit Root is the characteristic of a time series that makes it non- stationary. When the groups do not exhibit stationarity, differencing was performed. The whole concept of differencing is basically the calculation of differences among pairs of observations at some lag to make a nonstationary series stationary [19]. The amount of differencing done can be found in the d element of ARIMA (p, d, q).

The following table show results of the ADF test along with the model specifications, differencing, and the AIC lag. Also, the test statistic is significant if it is lesser than the critical value.

Table 1: Augmented Dickey-Fuller Test for Stationarity

Province/City	Model Specification Selected	Difference	AIC Lag	Test Statistic	Critical Value (α = 1%)	Critical Value (α = 5%)
Biliran	With constant & linear trend	1	1	– 6.06*	– 4.04	– 3.45
Eastern Samar	With constant & linear trend	1	1	– 4.59*	– 4.04	– 3.45
Northern Samar	With constant & linear trend	1	1	– 5.64*	– 4.04	– 3.45
Samar	With constant & linear trend	1	1	– 7.45*	– 4.04	– 3.45
Leyte	With constant & linear trend	1	1	– 5.78*	– 4.04	– 3.45
Southern Leyte	With constant & linear trend	0	1	– 3.47**	– 4.04	– 3.45
Tacloban City	With constant & linear trend	1	1	– 5.30*	– 4.04	– 3.45
Ormoc City	With constant & linear trend	1	1	– 9.52*	– 4.04	– 3.45

*Stationary at 1%

**Stationary at 5%

Table 1 shows the result of the ADF test for the time series of the provinces/cities in Eastern Visayas. All lags have been recommended by AIC to be one. The model was specified to test for both the drift (the constant term of a time series) and trend since it would be a problem to have them in the models.

As shown in the table, Southern Leyte was the only province that exhibited stationarity (at 5%) out of the eight provinces/cities without the need for differencing to be conducted. The other provinces/cities, namely, Biliran, Eastern Samar, Northern Samar, Samar, Leyte, Tacloban City, and Ormoc City needed a first-order differencing to obtain stationarity. After the differencing was done, these provinces/cities were observed to have stationarity at 1% significance level. Consequently, Southern Leyte will have an integrated element d equal to 0 while the rest of the provinces/cities have 1.

Model Selection

Since the data for Southern Leyte was not differenced, the Autocorrelation Function (ACF) and Partial Autocorrelation Function (PACF) can be used to determine the model since PACF determines the auto regression, or the p element, while the ACF determines the moving average, or the q element, in ARIMA (p, d, q). However, the researchers calculated the province's corrected Akaike Information Criterion (AICc) and Bayesian Information Criterion (BIC) for a more robust decision. Meanwhile, for the provinces/ cities that were differenced, the AICc and BIC were used since these groups were expected to have White Noise after the differencing. Samar and Ormoc City, however, had significant negative ACF and PACF but the correlations are small to conclude over differencing.

The computations are done plugging-in p and q terms to have candidate models. In selecting the models, the lower the value of the AICc and BIC, the better the model. In this sense, the lowest value is the best model possible based on that criterion.

Table 2: Optimal Models selected by the AICc and BIC for the provinces/cities in Eastern Visayas

Province City	p	q	AICc	BIC
Biliran	1	1	596.17	602.35
Eastern Samar	1	0	651.76	655.88
Northern Samar*	1	0	752.46	757.01
	2	2	752.13	763.08
Samar	0	1	858.42	862.91
Leyte	1	0	894.14	898.61
Southern Leyte	1	0	702.89	709.02
Tacloban City	1	0	673.17	677.33
Ormoc City**	0	1	609.6	613.76
	2	0	607.9	614.03

*ARMA(2,2) has greater log likelihood than ARMA(1,0). (-370.65 > -374.15)
** ARMA(2,0) has greater log likelihood than ARMA(0,1). (-300.76 > -302.7)

Table 2 shows the summary of the results of the AICc and BIC scores for the different provinces/cities in Eastern Visayas. The researchers examined several candidate models with different values of *p* (order of AR) and *q* (order of MA), with *p* and *q* capped at 3.

Biliran, with first-order differencing, has AICc and BIC agree that describes ARIMA(1, 1, 1) the best model for the province. The AICc and BIC results for Eastern Samar with first-order differencing shows that the AICc and BIC scores agree and describes ARIMA(1, 1, 0) as the best fit model for the province Northern Samar province, also with first-order differencing, has the best fit model using AICc found to be ARIMA(2, 1, 2), while ARIMA(1, 1, 0) was found to be the best model using BIC. Since the two methods have different best model, log likelihood was used. The log likelihood result shows that ARIMA(2, 1, 2) fits the data better than ARIMA(1, 1, 0). The scores of the AICc and BIC for Samar with first-order differencing agrees that the best model for the province is ARIMA(0, 1, 1).

Table 2 also shows the results of the AICc and BIC for the province of Leyte with first-order differencing. It can be observed in the table that the AICc and BIC agrees that the best model for Leyte is ARIMA(1, 1, 0). The AICc and BIC for Southern Leyte province without any differencing conducted agrees that the best model for the province is ARIMA(1, 0, 0). This model can also be obtained by just using the Autocorrelation Function and Partial Autocorrelation Function, which helps the case for this model since it was considered the best model by both AICc and BIC. Tacloban City with first-order differencing has both AICc and BIC scores agree that the best model for the city is ARIMA(1, 1, 0). Ormoc City, also with first-order differencing, has the best fit model using AICc found to be ARIMA(2, 1, 0), while ARIMA(0, 1, 1) was found to be the best model using BIC. Since the two methods have different best model, log likelihood was used. The log likelihood result shows that ARIMA(2, 1, 0) fit the time series data better than ARIMA(0, 1, 1).

Table 3: ARIMA Models for the COVID-19 Cases by Province/City in Eastern Visayas

Province/City	ARIMA Model
Biliran	ARIMA(1, 1, 1)
Eastern Samar	ARIMA(1, 1, 0)
Northern Samar	ARIMA(2, 1, 2)
Samar	ARIMA(0, 1, 1)
Leyte	ARIMA(1, 1, 0)
Southern Leyte	ARIMA(1, 0, 0)
Tacloban City	ARIMA(1, 1, 0)
Ormoc City	ARIMA(2, 1, 0)

The tabular presentation on Table 3 shows the time series models for the COVID-19 cases by province/city in Eastern Visayas. The table shows the summary of the ARIMA(*p*, *d*, *q*) models wherein *p* is the autoregressive (AR) element, *d* is the integrated (I) element, and *q* is the moving average (MA) element that were selected previously.

Forecasted Positive COVID-19 Cases in Eastern Visayas for Morbidity Week 36 – 43 of 2021

The objective of this study is to forecast the COVID- 19 cases of the provinces/cities for the next eight weeks which is Morbidity Week 36 – 43 of 2021 (September 5 October 30). To accomplish this objective, the ARIMA models were utilized to forecast the said eight weeks. The dataset from the week the province/city first reported a positive case to morbidity week 35 of 2021 was used to forecast the positive cases for morbidity weeks 36 to 43 of 2021.

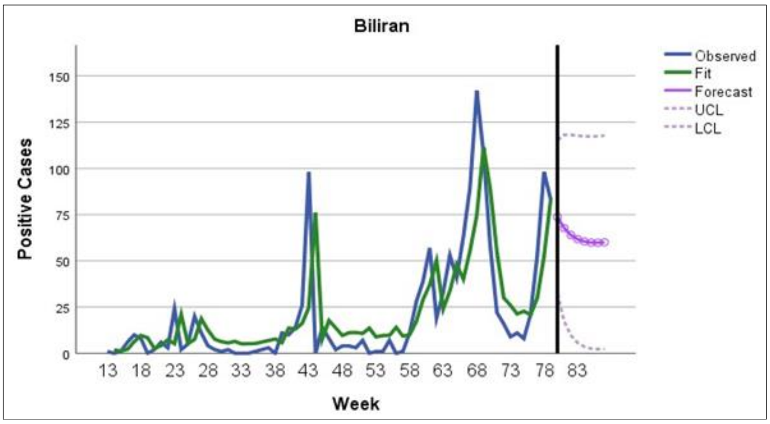

Fig 1: ARIMA(1, 1, 1) for Biliran COVID-19 Cases

Figure 1 shows the actual and the fitted weekly COVID-19 cases in Biliran from May 24, 2020 – September 4, 2021. The ARIMA(1, 1, 1) model was used to forecast the COVID-19 cases of Biliran for Morbidity Week 36 – 43 of 2021. Using the data from May 24, 2020

September 4, 2021, it was estimated that the highest forecasted weekly COVID-19 case in the province was in week 80 or Morbidity Week 36 of 2021, with an estimate of 74 individuals, while the lowest was in week 84 – 87, or Morbidity Week 40 – 43 of 2021, with 60 individuals. The figure also reveals that the weekly cases in Biliran will slightly decrease after week 84-87.

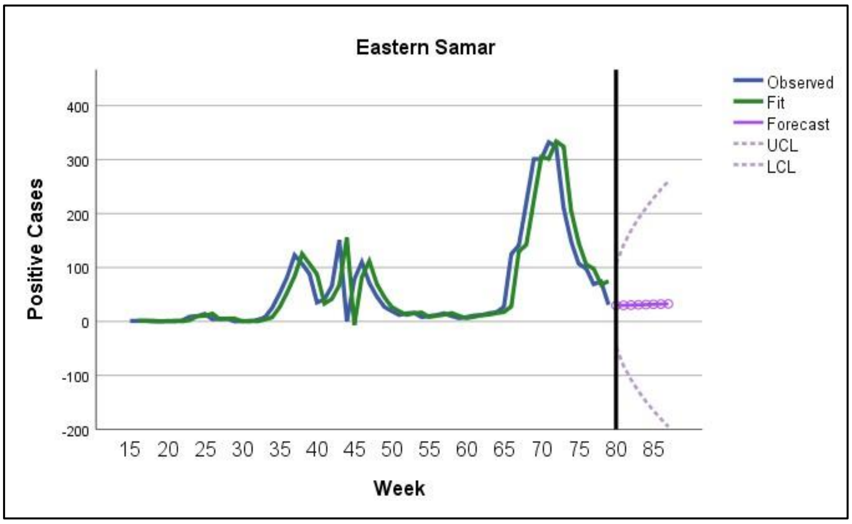

Fig 2: ARIMA(1, 1, 0) for Eastern Samar COVID-19 Cases

Figure 2 shows the actual and the fitted weekly COVID-19 cases in the province of Eastern Samar from June 7, 2020 – September 4, 2021. ARIMA(1, 1, 0)

model was used to forecast the COVID-19 cases of Morbidity Week 36 – 43 of 2021. Using the data from June 7, 2020 – September 4, 2021, the highest forecasted COVID-19 cases in the province was in week 85 – 87, or Morbidity Week 41 – 43 of 2021, with an estimate of 32 individuals, and the lowest was in week 80 – 82, or Morbidity Week 36 – 39 of 2021, with 30 individuals. The plot also shows that the weekly cases in Eastern Samar is predicted to slightly increase after week 80.

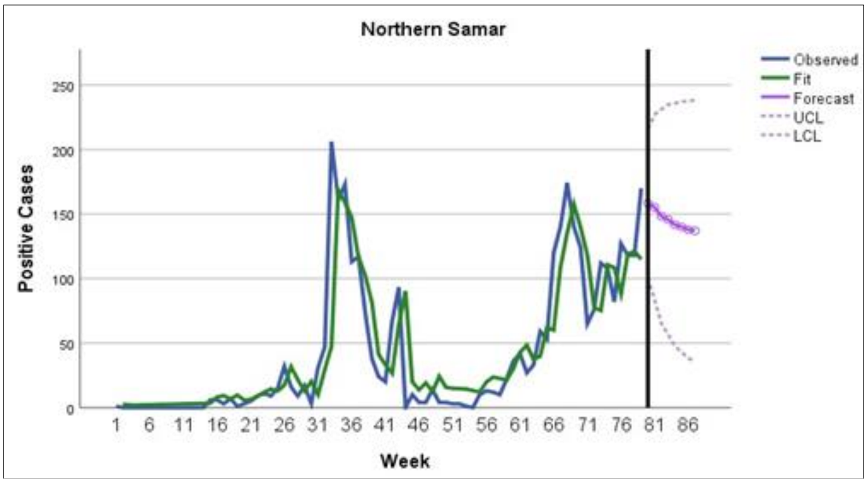

Fig 3: ARIMA (2, 1, 2) for Northern Samar COVID-19 Cases

Figure 3 shows the actual and the fitted weekly COVID-19 cases in the Northern Samar province from March 1, 2020 – September 4, 2021. ARIMA(2, 1, 2) model was used to forecast the COVID-19 cases of Northern Samar for Morbidity Week 36 – 43 of 2021. Using the data from March 1, 2020 – September 4, 2021, it was estimated that the highest forecasted COVID-19 cases in the province was in week 80, or Morbidity Week 36 of 2021, with an estimate of 158 individuals, while the lowest was in week 87, or Morbidity Week 43 of 2021, with 137. It was also revealed that the weekly cases in Northern Samar will have a gradual decrease.

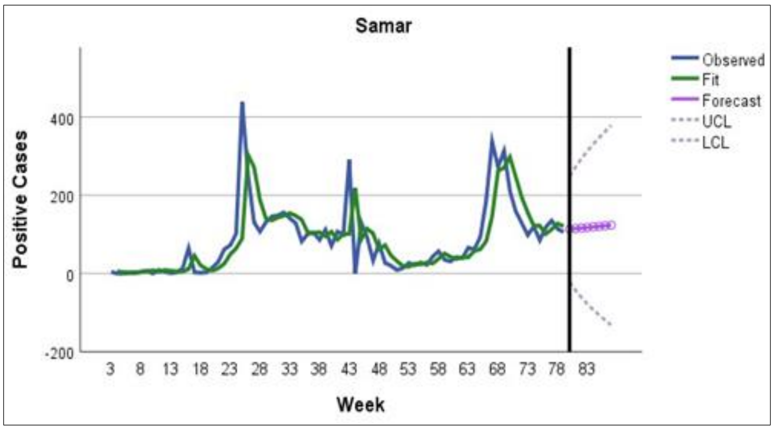

Fig 4: ARIMA(0, 1, 1) for Samar COVID-19 Cases

Figure 4 shows the actual and the fitted weekly COVID-19 cases in Samar from March 15, 2020 – September 4, 2021. The ARIMA(0, 1, 1) model was used to forecast the COVID-19 cases of Samar for Morbidity Week 36 – 43 of 2021. Using the data from March 15, 2020 – September 4, 2021, the forecasts show an increase in the weekly COVID-19 cases. The highest forecasted COVID-19 cases in the province was in week 87, or Morbidity Week 43 of 2021, with an estimate of 123 individuals, while the lowest was in week 80, or Morbidity Week 36 of 2021, with 113.

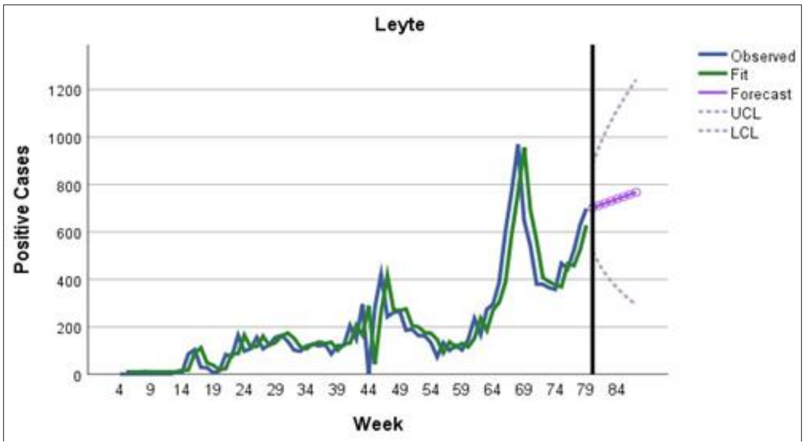

Fig 5: ARIMA(1, 1, 0) for Leyte COVID-19 Cases

Figure 5 shows the actual and the fitted weekly COVID-19 cases of the province of Leyte from March 22, 2020 – September 4, 2021. The ARIMA(1, 1, 0) model was used to forecast the COVID-19 cases of Leyte for Morbidity Week 36 – 43 of 2021. Using the data from March 22, 2020 – September 4, 2021, it was revealed that the weekly cases in Leyte will increase. The highest forecasted COVID-19 cases in the province was estimated to be in week 87, or Morbidity Week 43 of 2021, with an estimate of 767 individuals, while the lowest was in week 80, or Morbidity Week 36 of 2021, with 702. When cases are relatively high and an increase is expected like this, leaders in the local governments should consider tightening the restrictions.

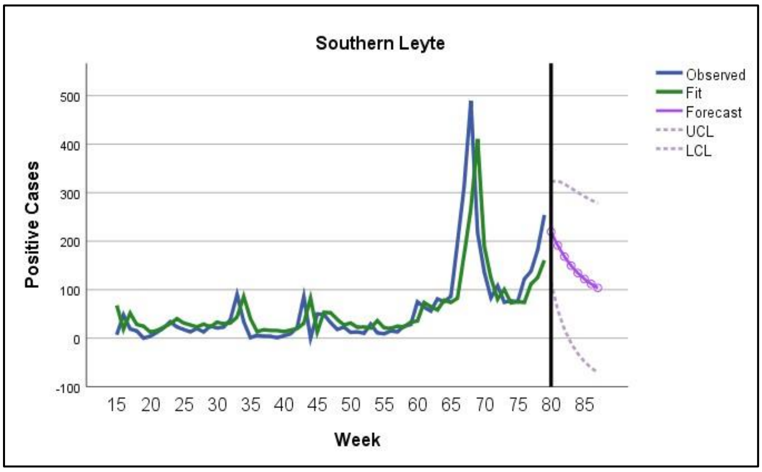

Fig 6: ARIMA(1, 0, 0) for Southern Leyte COVID-19 Cases

Figure 6 shows the actual and the fitted weekly COVID-19 cases in Southern Leyte province from June 7, 2020 – September 4, 2021. ARIMA(1, 0, 0) was used to forecast. The COVID-19 cases of the province for Morbidity Week 36 – 43 of 2021. Using the data from June 7, 2020 – September 4, 2021, it was estimated that the highest forecasted COVID-19 cases in the province was in week 80, or Morbidity Week 36 of 2021, with an estimate of 219 individuals, while the lowest was in week 87, or Morbidity Week 43 of 2021, with 104 individuals. It was also revealed that the weekly cases in Southern Leyte will exponentially decrease.

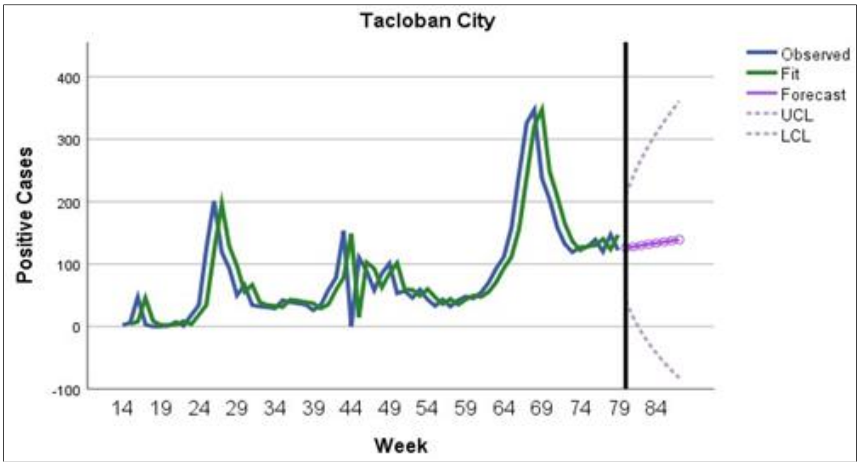

Fig 7: ARIMA(1, 1, 0) for Tacloban City COVID-19 Cases

Figure 7 shows the actual and the fitted weekly COVID-19 cases in Tacloban City from May 31, 2020 – September 4, 2021. ARIMA(1, 1, 0) model was used to forecast the COVID-19 cases of Tacloban City for Morbidity Week 36 – 43 of 2021. Using the data from May 31, 2020 – September 4, 2021, it was revealed that the weekly cases in Tacloban City is set to slightly increase. The highest forecasted COVID-19 cases in the city was in week 87, or Morbidity Week 43 of 2021, with an estimate of 139 individuals, while the lowest was in week 80, or Morbidity Week 36 of 2021, with 126 individuals.

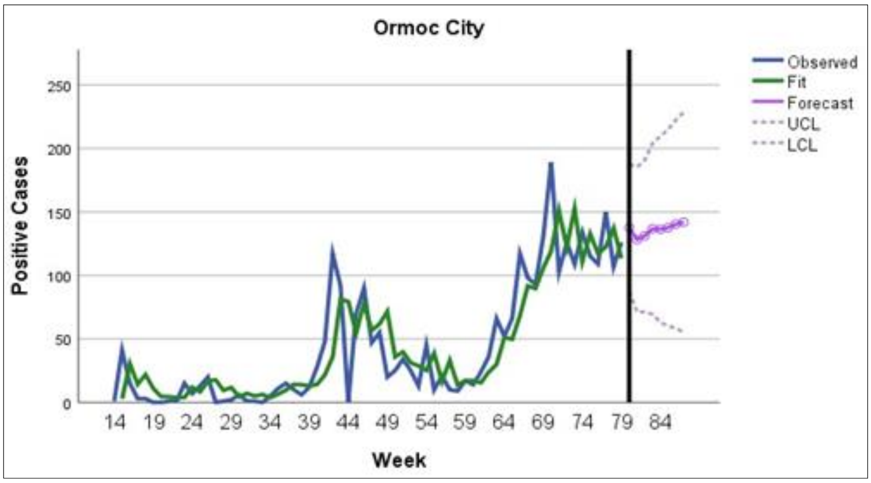

Fig 8: ARIMA(2, 1, 0) for Ormoc City COVID-19 Cases

Figure 8 shows the actual and the fitted weekly COVID-19 cases in Ormoc City from May 31, 2020 – September 4, 2021 for the ARIMA(2, 1, 0) model. Using the data from May 31, 2020 – September 4, 2021, it was estimated that the highest forecasted COVID-19 cases in the province was in week 87, or Morbidity Week 43 of 2021, with an estimate of 142 individuals, while the lowest was in week 81, or Morbidity Week 37 of 2021, with 128. The alternating increase and decrease of the forecasted COVID-19 cases shows that it follows the pattern it has in the original dataset. Although it is alternating, an obvious increase can still be observed.

Table 4: Forecasted Positive COVID-19 Cases in Eastern Visayas for Morbidity Week 36 to 43 of 2021 (September 5 – October 30)

COVID-19 Positive Cases	Biliran	Eastern Samar	Northern Samar	Province/City		Southern Leyte	Tacloban City	Ormoc City
				Samar	Leyte			
Morbidity Week 36	74	30	158	113	702	219	126	138
Morbidity Week 37	68	30	155	115	712	191	128	128
Morbidity Week 38	64	30	148	116	721	168	130	131
Morbidity Week 39	62	31	146	118	730	150	132	137
Morbidity Week 40	60	31	142	119	739	134	133	136
Morbidity Week 41	60	32	140	121	749	122	135	138
Morbidity Week 42	60	32	138	122	758	112	137	140
Morbidity Week 43	60	32	137	123	767	104	139	142
Total	508	248	1164	947	5878	1200	1060	1090
Mean	64	31	146	118	735	150	133	136

Table 4 shows the forecasted COVID-19 positive cases in Eastern Visayas by province/city. The dataset from the week the province/city first reported a positive case to morbidity week 35 of 2021 was used to forecast the positive cases for morbidity weeks 36 to 43 of 2021.

Using the tabular presentation in Table 4, it can be observed that Leyte has the highest total of forecasted cases with 5,878 and an average forecasted infections of 735 per week, followed by Southern Leyte with 1,200 and an average forecasted infections of 150 per week. Northern Samar was forecasted to have 1,164 with an average of 146, Ormoc City with 1,090 and an average of 136, Tacloban City with 1,060 and a mean of 133, Samar with 947 and an average forecasted infections of 118 per week, Biliran with 508 and an average of 64, while Eastern Samar was forecasted to have the lowest total with 248 cases and an average forecasted infections of 31 per week over the eight-week period.

Conclusion

In this study, the dataset used was from the week the province/city first reported a positive case to morbidity week 35 of 2021. ARIMA models were used to model the reported cases in the different provinces/cities of Eastern Visayas and forecast the positive cases for morbidity weeks 36 to 43 of 2021. The provinces/cities are Biliran, Eastern Samar, Northern Samar, Samar, Leyte, Southern Leyte, Tacloban City, and Ormoc City.

The COVID-19 cases for Biliran was forecasted to slightly decrease for the eight-week period, Eastern Samar's cases was forecasted to slightly increase, Northern Samar's cases was expected to have a gradual decrease, and the province of Samar's cases was forecasted to increase.

In addition, the COVID-19 cases of Leyte were expected to increase, which can be a problem to the community since cases are relatively high and if an increase like this is expected, leaders in the local governments should consider tightening the restrictions. Meanwhile, Southern Leyte's cases was forecasted to exponentially decrease. Tacloban City and Ormoc City COVID-19 cases was forecasted to increase, although Ormoc City has alternating increase and decrease of the forecasted COVID-19 cases an obvious increase can still be observed.

Leyte has the highest total of forecasted cases, followed by Southern Leyte, while Eastern Samar was forecasted to have the lowest total over the eight-week period.

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References

1. World Health Organization (WHO). Coronavirus disease 2019 (COVID-19) Situation Report – 51, 75. 2020a. Available from: https://www.who.int/docs/default-source/coronaviruse/situation-reports/
2. Ghinai I, McPherson T, Hunter J, Kirking H, Christiansen D, Joshi K, *et al*. Illinois COVID-19 Investigation Team. First known person- to-person transmission of severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) in the USA. The Lancet, 2020.
3. World Health Organization (WHO). Infection Prevention and Control of Epidemic-and Pandemic-prone Acute Respiratory Infections in Health Care. Geneva: World Health Organization, 2014. Available from: https://apps.who.int/iris/bitstream/handle/10665/112656/9789241507134_eng.pdf;jsessionid=41AA684FB64571CE8D8A453C4F2B2096?sequence=1
4. World Health Organization (WHO). Transmission of SARS-CoV-2: implications for infection prevention precautions, 2020. Available from: https://www.who.int/news-room/commentaries/detail/transmission-of-sars- cov-2-implications-for-infection-prevention- precautions
5. Qu JM, Cao B, Chen RC. COVID-19: The Essentials of Prevention and Treatment. Elsevier, 2020. ISBN: 978-0-12-824003-8
6. World Health Organization (WHO). Listings of WHO's response to COVID-19, 2020. Available from: https://www.who.int/news/item/29-06-2020-covidtimeline
7. World Health Organization (WHO) Europe. Coronavirus disease (COVID-19) pandemic, 2020. Available from: https://www.euro.who.int/en/health-topics/health- emergencies/coronavirus-COVID-19/novel- coronavirus-2019-ncov
8. World Health Organization (WHO). Coronavirus disease 2019 (COVID-19) Situation Report – 51, 75, 2020a. Available from: https://www.who.int/docs/default-source/coronaviruse/situation-reports/
9. Department of Health (DOH). DOH confirms local transmission of COVID-19 in PH; reports 6th case, March 7, 2020a. Available from: https://www.doh.gov.ph/doh-press-release/doh-confirms-local-transmission-ofCOVID-19-in-

ph#:~:text=The%20Department%20of%20Health%20(DOH,had%20no%20recent%20travel%20history
10. Ramzy A, May T. Philippines reports first coronavirus death outside China, February 2. The New York Times, 2020. Available from: https://www.nytimes.com/2020/02/02/world/asia/philippines-coronaviruschina.html
11. Sam DS, Pokhariyal GP, Rogo K, Ndhine EO. Otoi-NARIMA model for forecast seasonality of COVID-19 waves: case of Kenya. Int. J. Stat. Appl. Math. 2021;6:48-58.
12. CNN Philippines. COVID-19 cases among healthcare workers now at 1,245; death toll at 27. CNN Philippines, April 27, 2020a. Available from: https://www.cnnphilippines.com/news/2020/4/27/covid-cases-PHhealthworkers.html
13. McCarthy J. Pandemic claims the lives of doctors in the Philippines at startling rates, April 3. National Public Radio (NPR), 2020. Available from: https://www.npr.org/sections/coronavirus-live-updates/2020/04/03/826804519/pandemicclaims-doctors-in-the-philippines-at-startling-rates
14. Philippine Statistics Authority (PSA). 2020 Census of Population and Housing, 2021.
15. University of Washington. Unit Root Tests. Notes:
16. Econ584 – Economic Theory II. Available from: https://faculty.washington.edu/ezivot/econ584/notes/unitroot.pdf
17. Burnham K, Anderson D. Model Selection and Multi-Model Inference: A Practical Information-Theoretic Approach. Springer, 2004.
18. Hurvich C, Tsai CL. Regression and time series model selection in small samples. Biometrika. Oxford University Press, 1989.
19. Chen YC. Lecture 7: Model Selection and Prediction. STAT 535: Statistical Machine Learning. University of Washington,2019. Available from: http://faculty.washington.edu/yenchic/19A_stat535/Lec7_model.pdf
20. Tabachnick B, Fidell L. Using Multivariate Statistics (6th Ed.). Pearson, 2013.
21. Vallejo BM, Ong RAC. Policy responses and government science advice for the COVID 19 pandemic in the Philippines: January to April 2020. Progress in Disaster Science (2020). Elsevier, 2020.