

## Research Article

## Analyzing Trends and Predicting Future Outbreaks of Measles in the Philippines Using Time Series and ARIMA Mathematical Models

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### Abstract

**Background:** Analyzing disease data like measles can provide decision-making inputs to the health sector in the country. Further, providing data as to the number of possible cases of the disease in the future is vital for the authority and to the people leaving the affected locality. Since measles is categorized as highly contagious disease by the Department of Health, attention to its outbreaks should be considered by the authority.

**Methods:** The paper analyzed the trend and provide a five-year forecasted data of the Measles in the Philippines that will serve as inputs to the authority in designing mediation scheme to mitigate its future outbreaks. Time series and ARIMA models are the tools used in the study.

**Results:** Results showed that there was a decreasing pattern of the disease from 2017 to 2020. However, there was a decreasing pattern of its occurrence in the next five years based on the five-year forecast. Nonetheless, there is a need in improving the different mitigation plans of the authority in mitigating the occurrence of the disease though it yielded a decreasing pattern.

**Conclusions and Implications for Translation:** The data presented in the study may be used as baseline in designing an effective intervention plans of the health sectors in the Philippines. Through the data forecasted in the next few years, the health sectors from the national level down to barangay level may be aware of its occurrences and eventually design an effective plan in their respective areas in order to protect their constituents.

**Key words:** Data Mining • Disease Outbreaks • Prediction Model • Trend Analysis

### Introduction

One of the most contagious viral infection showing a yearly increased morbidity and mortality, particularly to children is measles [1,2]. The disease showed common symptoms such as runny nose, cough, red and watery eyes, and small white spots inside the cheeks [2-4]. In 2019, the Philippines experienced continuous outbreaks of measles [5]. In the global perspective, there was an increasing trend of measles across all regions [6], with the re-emergence of endemic and outbreaks in some countries that had previously achieved none occurrence level. Some countries are having high rates of measles vaccination [7,8] experience outbreaks by virtue of imported cases causing transmission through susceptible groups of individuals who are not immune to the measles virus. Countries like the United States, Netherlands, and United Kingdom, measles was declared eliminated where the disease is no longer constantly present in the country [9]. The outbreak continuously occurred in countries around the world including the Philippines.

Several literature and studies in the field of data mining has gained popularity in different research arenas because of its infinite methodologies and applications to mine information in a correct format [15].

In China, Wang, Shen, Jiang, et al. adopted ARIMA in fitting the monthly incidence of Hepatitis B from March 2010 to October 2017 [16]. Liu and colleagues forecasted the incidence of hand, foot and mouth disease in Sichuan province [17]. In the study conducted by Anwar and company, the data from January 2005 until September 2015 was employed to describe the malaria incidence in Afghanistan [18]. Thus, the ARIMA model effectively predicts a high incidence recording of reported cases [19]. Sato presented the process of using the ARIMA model on disease management, where the short period segments were encouraged to analyze each disease [19]. Several countries use the ARIMA model in forecasting the SARS-COV-2 diseases, including the Islamic Republic of Iran, Pakistan, Australia [20-22].

Other examples of the ARIMA model were applied in the COVID-2019 epidemic sets [23,24]. In India, the spatial prediction of COVID-2019 resulted to the accurate and effective epidemiological surveillance of high vulnerabilities in west and south Indian districts [20]. The ARIMA model was used to predict the estimated confirmed cases, deaths, and recoveries for the several countries namely United States, United Kingdom, Turkey,

China, Russia, Germany, Iran, Brazil, Italy, Spain, France, Switzerland, Germany from April 24 to July 7, 2020 [21,24].

Data showed that measles cases in the Philippines is still high in terms of the number of infected individuals among other countries in Asia [10]. Thus, monitoring and preparing mitigations plan is needed in order to lower down the number of infections in the country. The study provides input to the authority through trend analysis of the occurrences of the disease and at the same time provides predictive figures in order to visualize its spread in the near future.

## Methods

This study employs data from the different health sectors situation reports from January 2017 until February 2021. The different health agencies are Republic of the Philippines National Disaster Risk Reduction and Management Council (NDRRMC), Department of Health, Epidemiology Bureau, Public Health Surveillance Division, and International Federation of Red Cross and Red Crescent Societies.

Measles incidence in the Philippines was forecasted using Autoregressive Integrated Moving Average (ARIMA) model employed in many fields to construct models for forecasting time series [22,27]. ARIMA(p,d,q) model is used to forecast the data pattern of diseases for the next fourteen years. Time-series predictions are basically based on the changes over time in historical data sets and can produce mathematical models by using statistical data that can be extrapolated [28-30]. The ARIMA (p,d,q) model is defined as follows:

$$X_t = \Phi_1 X_{t-1} + \dots + \Phi_p X_{t-p} + a_t - \Theta_1 a_{t-1} - \dots - \Theta_q a_{t-q} \quad (1)$$

where:

$\Phi$ 's (phis) introduces the autoregressive parameters for estimation,  $\Theta$ 's (thetas) represents the moving average parameters, the main series is represented by X's, and the a's were the unknown random errors which are assumed to follow the normal probability distribution.

Three steps were performed to predict the measles cases by utilizing the ARIMA related modules. The model used autocorrelation analysis and partial auto-correlation analysis procedure to analyze random, stationery, and seasonal effects on time-series data. The proponent of the study prepared a stationary time series by considering the differences. Further, determined plausible models on the basis of an autocorrelogram and a partial autocorrelogram. Lastly, the parameter estimation and model testing were used to compare the plausible models obtained, and we selected the most appropriate model. Finally, we conducted a predictive analysis of historical data. The study used GRET (Gnu Regression, Econometrics and Time-series Library) software for plotting the graphs and analysis of the data sets.

## Results and Discussion

Figure 1: presents the architectural design in predicting measles trends.

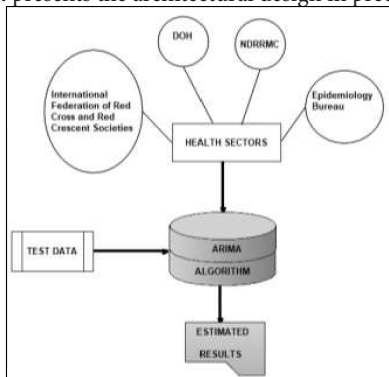


Figure 1: Predicting Measles Trends

## Discussion

The trends of measles from the year 2017 to 2020 in the Philippines through the time-series is presented in Figure 2. Results showed that there was a rapid increase of the disease in the year 2019 which is the highest incidence in the span of four (4) years and eventually data showed a decrease pattern from its peak in 2019 to 2020. Results indicate that intervention strategies of the authority are more likely effective based on the data. The result could be supported by the report of Mahase [9] that Measles cases have an evident increase by 300% so far in 2019 as compared with the same period in 2018 based on the data of the World Health Organization. Dyer [30] reported in his study that in the Philippines, 70 people, mostly children, died of measles in the first six weeks of 2019, based on the statement of the Philippines health ministry. This came after 18 000 measles cases were reported by the country in 2018, a large increase from 2400 in 2017. Dyer [30] further noted that from 2014 to 2017, measles vaccination rates in the Philippines fell from 88% to 73% before dropping to 55% in 2018.

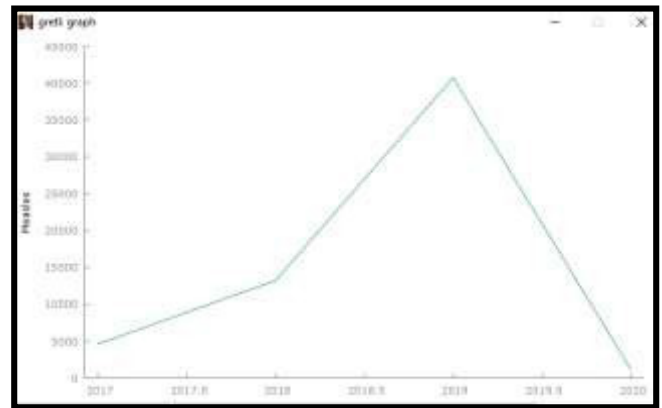


Figure 2: The Time-Series Plot of Measles in the Philippines

In order to determine the possible occurrence of the disease in the future, the study forecasted its occurrence in the next four (4) years. Through the use of Autoregressive Integrated Moving Average (ARIMA) the study was able to produce the forecasted data. It is evident in the figure that there will be a slight decrease of the disease in 2021 and a slight increase in the year 2023.

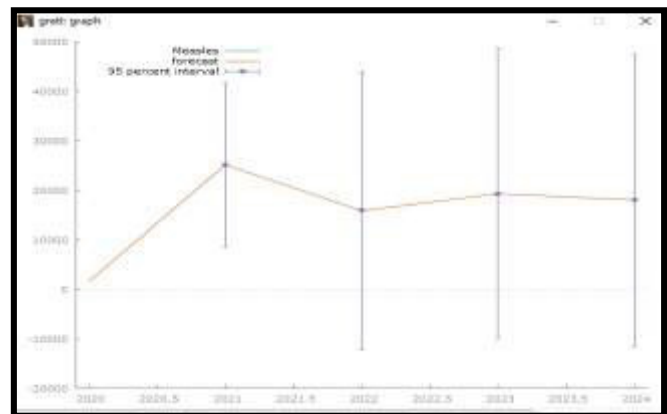


Figure 3: A Five-Year Forecast

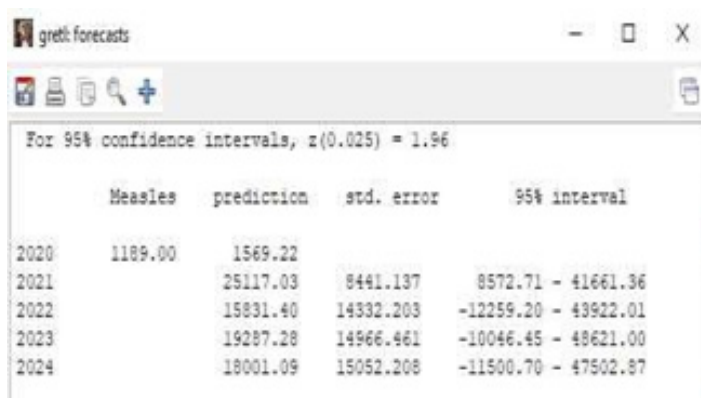


Figure 4: Detailed Forecast Results

## Conclusions and Implications for Translation

Majority of the organizations today are relying on the data that they are having as an aid in their decision-making undertakings. Thus, the government organizations like the Department of Health are making use of their information on the different diseases for their intervention programs. The study successfully use the time-series tool to produce the trends of the measles in the Philippines and at the same time the ARIMA (1,0,1) model helped in predicting the different cases. An increasing pattern is evident of the disease from 2017 to 2021. However, data showed a decreasing pattern of the disease in the next five years through the ARIMA model. Thus, the Department of Health should strengthen their campaign to the community in taking seriously the different programs of the agency for the benefit of everybody in the society. Obtaining forecasted data on the occurrences of measles cases in very helpful to the administration in designing preventive measures against the spread of cases. In the study, the time-series tool successfully presented the trends of the disease in the country, and ARIMA (1,0,1) model helps in predicting the increasing and decreasing pattern of the measles cases. There was an increased pattern of the disease in the country from 2016 until 2019, based on historical data. However, in the next five years, there will be a decreasing number of its occurrence based on the results of the forecast. With the current situation and the future figure of measles disease in the country, there is still a need to strengthen the campaign by the Department of Health to the community in dealing with how to prevent oneself from the infection and at the same time to revisit previous intervention plans and programs and evaluate which part of the plans that need to be focused as a way to prevent that spread of the infections.

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