Prevalence of Dengue Fever (DF) and Dengue Hemorrhagic Fever (DHF): A Description and Forecasting in Iligan City, Philippines

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Date received: June 15, 2012
Revision accepted: November 27, 2012

Abstract

This study presents the prevalence of dengue fever (DF) and dengue hemorrhagic fever (DHF) cases admitted at Mindanao Sanitarium and Hospital (MSH), Iligan City from the year 2000-2008. A total of 606 cases were reported to have DHF and 993 for DF. For DHF, 51.81% were males and ages 4-12 contributed 60.73% of the reported cases. In the 993 cases of DF, it has been noted that 55.09% were males; ages 7-34 showed higher DF susceptibility (72.21%). Majority of the dengue cases reported as of 2000-2004 are coming from Iligan City. Also, a possible alternating increase-decrease-increase pattern in the number of cases in each year has been noted to be consistent throughout the study period. Furthermore, this study tries to develop a univariate time series model forecasting the monthly occurrence of dengue cases at MSH. The results showed that the autoregressive integrated moving average forecast curves were consistent with the pattern of the observed values. Identification of the predominant dengue serotypes that are most common in Iligan city and nearby localities is one of the strongest recommendations of this study. Further recommendations include: (1) analyses of other patients' profile like blood type, stress factors, and diet, (2) dissemination of this study's result to the public via forums and (3) expansion of the research locale.

Keywords: dengue fever, dengue hemorrhagic fever, prevalence, ARIMA

1. Introduction

Due to its recent serious emerging health threats, together with possible dire consequences including death, dengue fever, as caused by dengue virus infection (though not a new disease), has aroused considerable medical and public health concerns worldwide and is considered one of the most important arthropod-borne viral diseases in humans in terms of morbidity and mortality. Dengue cases were formally included within the disease portfolio of the United Nations Development Programme/World Bank/World Health Organization Special Programme for Research and Training in Tropical Diseases by the Joint Coordination Board in June 1999. Dengue's global prevalence has grown dramatically in recent decades. This disease is now endemic in more than a hundred countries in Africa, the Americas, eastern Mediterranean, SE Asia and the Western Pacific, threatening more than 2.5 billion people. An approximated estimate of 50 to 100 million cases worldwide occur every year which includes 200,000 to 500,000 cases of potential life-threatening dengue hemorrhagic fever (DHF)/ dengue shock syndrome (DSS), characterized by thrombocytopenia and increased vascular permeability (Noisakran and Perng, 2007; Pei-Yun and Jyh-Hsiung, 2004).

Dengue fever and dengue hemorrhagic fevers are classified as classic viral hemorrhagic fevers brought about by *Aedes* spp. The former is milder and is most common in the Caribbean and South America while the later can induce shock in the victim (usually a child) and kill in a few hours and is a leading cause of death among Southeast Asian children (Tortora *et al.*, 2001).

Where the human population occurs in rural villages or islands, an epidemic transmission cycle may occur. Viruses that are introduced quickly infect the majority of susceptible persons in these areas, and increasing herd immunity causes the virus to disappear from the population. Depending on the geographical area, *Aedes* spp. may act as vectors. By the bite of an infected mosquito, humans will be infected with dengue viruses. *A. aegypti,* the principal vector, and a highly domesticated tropical mosquito that prefers laying its eggs in artificial containers commonly found in and around homes (flower vases, automobile tires, etc). Adult mosquitoes tend to rest indoors, unobtrusive, where feeding on humans during daylight hours is their preference. Two biting activity peaks had been identified: early morning for 2 to 3 hours after daybreak and in the afternoon for several hours before dark, though they feed all day indoors and on overcast days. Female mosquitoes are sensitive feeders since their feeding will be disrupted at the slightest movement, and later return to the same or different person to continue feeding. This behavior then leads to multiple infections, if the mosquito is infective, in a short time even if they only prove without taking blood. Thus, it is not surprising to see several family members of the same household to be infected with dengue virus within 24- to 36-hour time frame, where infection from a single mosquito is not impossible. During infection, the virus undergoes an incubation period of 3 to 14 days, after which the person may experience acute onset of fever with various nonspecific signs and symptoms. During this acute febrile period that would lasts from 2 to 10 days, dengue viruses may circulate in the peripheral blood. If other *A. aegypti* mosquitoes bite the ill person during this febrile viremic stage, the mosquito may be infected and subsequently transmit the virus to other uninfected persons (Gubler, 1998).

Four dengue virus serotypes had been identified: DEN-1, DEN-2, DEN-3 and DEN-4 which belongs to the genus *Flavivirus,* family *Flaviviridae* and contains approximately 70 viruses. Flaviviruses are relatively small (40-50 mm) and spherical with a lipid envelope. They have common epitopes on the envelope protein that result in extensive cross-reactions in serologic tests. These make unequivocal serologic diagnosis of flavivirus difficult, which is especially true among the four dengue viruses. A dengue serotype infection provides lifelong immunity to that virus but no cross-protective immunity to the other three serotypes. Thus, a person residing in an endemic dengue area can be infected with three, and probably four, dengue serotypes during their lifetime (Gubler, 1998).

Dengue studies had been conducted in different localities like Thailand, the Mexico-Texas border, Puerto Rico, Indonesia and the Philippines, where each locality is differently focusing on the microevolution of the different strains, clinical diagnosis, household-based sereoepidemiologic survey, and the epidemiology of the disease in local residents (Carlos *et al.*, 2005; Ramos *et al.,* 2008; Porter *et al.,* 2005; Perez *et al.,* 2001; Jarman *et al.,* 2008).

Dengue is an endemic viral disease affecting tropical and subtropical regions around the world, predominantly in urban and semiurban areas. Dengue fever (DF) and its more serious forms, dengue hemorrhagic fever (DHF) are becoming important public health problems and were formally included within the disease portfolio of the World Health Organization Special Programme for Research and Training in Tropical Diseases by the Joint

Coordination Board in June 1999 (WHO, 1999 as cited by Huang, *et. al*, 2004).

Dengue virus causes a wide spectrum of illnesses, ranging from inapparent, flu-like mild undifferentiated fever, and classical DF to the more severe form, DHF-DSS, from which rates of morbidity and mortality are high (Huang, *et. al*, 2004). Additionally, DF is characterized by fever of 3 to 5 days' duration, headache, muscle and joint pain, and a rash, which is self-limited and from which patients usually recover completely. There is no specific treatment for DF, and most forms of therapy are supportive in nature (Huang, *et. al*, 2004)

This study aimed to describe the demographic characteristics of the admitted patients in terms of age, gender and their place of origin and to develop a univariate time series model for the monthly dengue fever (DF) and dengue hemorrhagic fever (DHF) cases at Mindanao Sanitarium and Hospital located in Iligan City based on study period from 2000-2008 inclusively.

2. Methodology

This study was primarily conducted at Mindanao Sanitarium and Hospital, one of the tertiary hospital institutions in Iligan City, Lanao del Norte. A secondary data found in the Logbooks available at the Medical Records department of the said hospital. The researchers sought permission from the President of the hospital through the head of the medical records department where the necessary data to be gathered are on file. Upon approval of the letter, the researchers went over records of patients who were diagnosed of either dengue fever or dengue hemorrhagic. Specifically, their demographic characteristics such as: age, gender, place of residence or origin was noted. Lastly, counting the monthly number of DF and DHF from the year 2000-2008 was still considered.

This study utilized descriptive statistical technique as frequency and percentages to describe the important features of the data set in table or graphical forms. On the other hand, the tentative AutoRegressive Integrated Moving Average (ARIMA) models derived were analyzed with the Box-Jenkins method, which was suitable for a long a forecasting time. The Box-Jenkins method for identifying an appropriate ARIMA model for estimating and forecasting a univariate time-series consisted of tentative identification, estimation, diagnostic checking and forecasting (Promprou, S., *et. al*, 2006).

In this method, one must determine first whether the time series is stationary or not. After determining if the series is stationary by way of some transformation or differencing, an ARIMA model was developed. A tentative model was made to express the each observation as a linear function of the previous value of the series (autoregressive parameter) and of the past random shock (moving average parameter). The general form of this tentative model was given below:

$$Y_t = \delta + \varnothing_1 Y_{t-1} + \varnothing_2 Y_{t-2} + \cdots + \varnothing_p Y_{t-p} - \Theta_1 a_{t-1} - \Theta_2 a_{t-2} - \cdots - \Theta_q a_{t-q} + a_t \quad (1)$$

where:

Y_t = denotes the number of DF/DHF cases at time t.

Y_{t-1} = denotes the number of DF/DHF cases at time $t-1$.

Y_{t-p} = denotes the number of DF/DHF cases at time $t-p$.

$\varnothing_1, \varnothing_2, \ldots, \varnothing_p$ = autoregressive parameters (of order p).

$\Theta_1, \Theta_2, \ldots \Theta_p$ = moving average parameters (of order q).

a_t = denotes a time-series of random shocks or white noise process at time t.

a_{t-1} = denotes the white noise process at time $t-1$.

δ = is a constant term.

The random shock a_t is a value that is assumed to be randomly selected from a normal distribution that has a mean 0 and variance that is constant at every time period. The random shock $a_t, a_{t-1}, \ldots, a_{t-q}$ are assumed to be statistically independent.

The parameters of the tentative model from the identification stage were estimated using the ARIMA module in Statistical Package for the Social

Sciences (SPSS) version 13. The adequacy of the estimated tentative models was examined. Plotting the residuals against the predicted values of the estimated model was a useful diagnostic checking. The Box-Ljung statistic was used to determine if the ACF between residuals is correlated and/or the ACF of the residuals of the estimated models fell within the 95% confidence limits.

The final stage of testing the estimated ARIMA model was its ability to forecast.

3. Results and Discussion

Figures 1 and 2 present the summary of the descriptive measures of the observed data of Dengue Fever (DF) and Dengue Hemorrhagic Fever (DHF) cases from the year 2000-2008 in Mindanao Sanitarium and Hospital, Iligan City, Lanao del Norte.

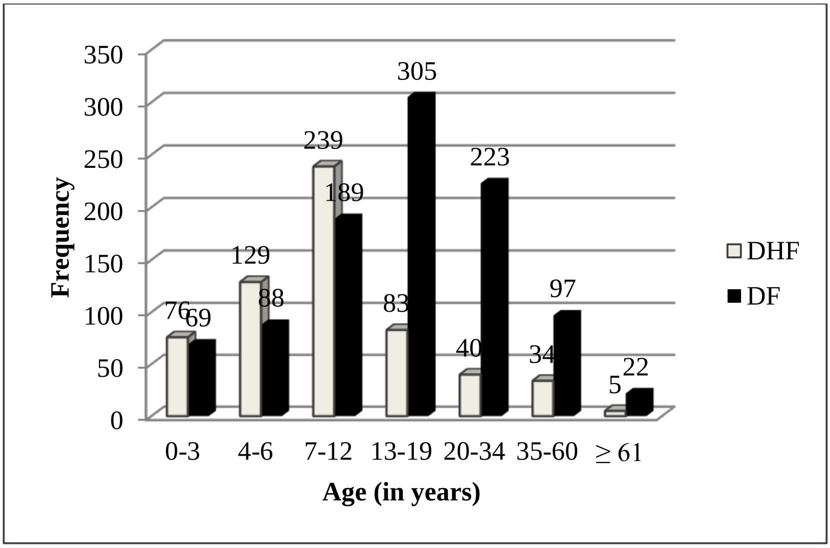

Figure 1. Distribution of DHF and DF Cases by Age

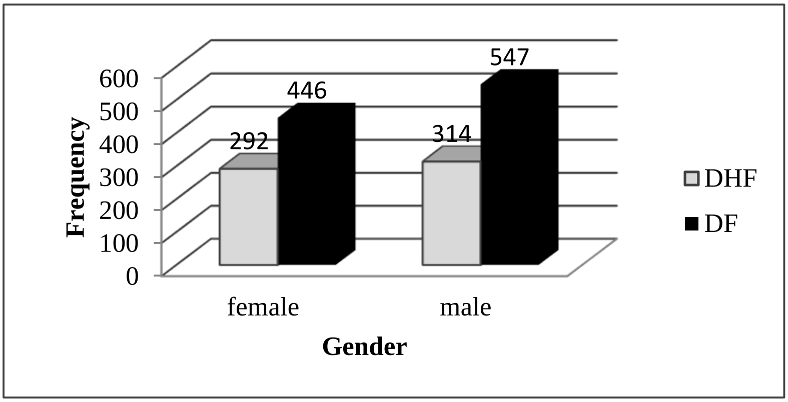

Figure 2. Distribution of DHF and DF Cases by Gender

A total of 1599 cases of both DF and DHF had been admitted at MSH from 2000-2008. It has been noted that 62.10% (993) of the total cases acquired DF and only 37.90% (606) for DHF where more males were admitted than females (53.85% and 46.15%, respectively).

Figure 3 reveals that the year 2000 has the lowest number of cases (1.75%) while the years 2005 and 2007 showed the highest (26.52% and 18.45%, respectively

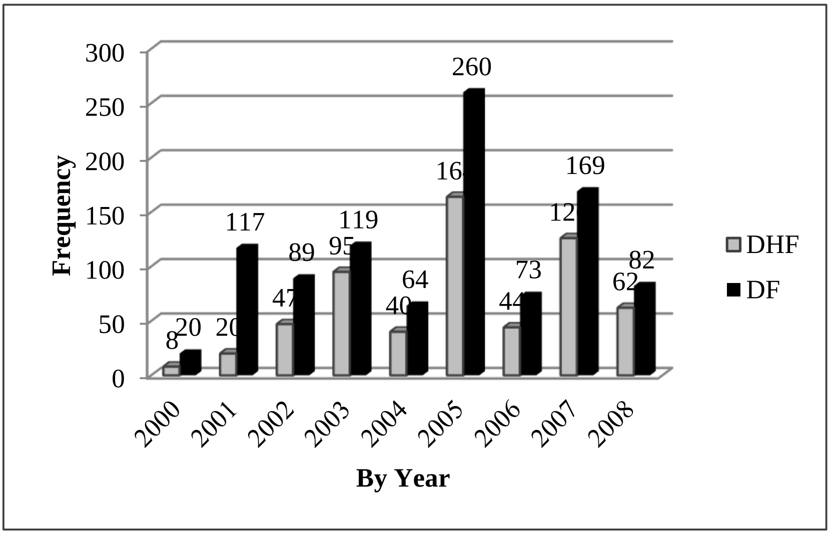

Figure 3. Distribution of DHF and DF by year

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Figure 4 reveals that cases of DF are higher in males (55.09%) than females (44.91%). This result is contradictory to the results of the study conducted by Cordeiro *et al.* (2007) where they presented that females are more susceptible than males in Pernambuco State, Brazil (1995-2006). But this contradiction of results may suggest farther knowledge that dengue cases in different localities may be affected by the serotype predominating a locality. Hence, this will try to suggest deeper studies of the serotype causing dengue diseases in Iligan City and nearby vicinities.

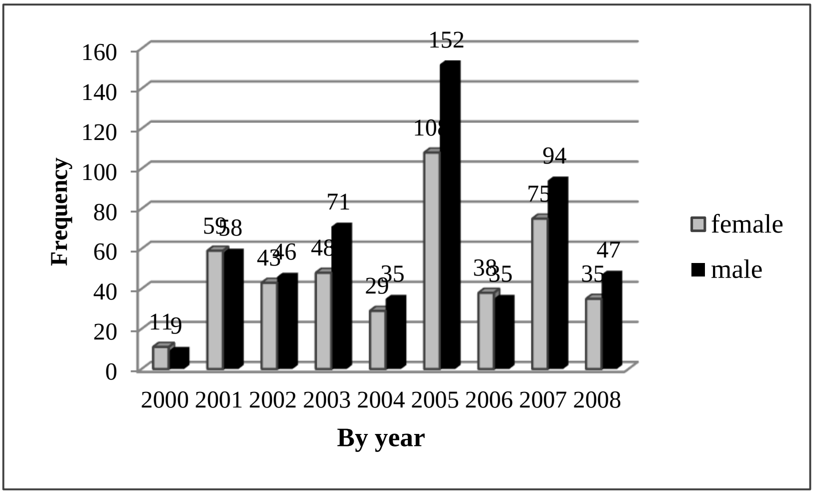


Figure 4. Distribution of DF according to Gender for 2000-2008

Also, reflected in Figure 5, gender relationship to DHF in the years 2008-2009 reveals that 51.82% of the reported hospital cases are males. This result tries to suggest that Iligan City and nearby vicinities have a population where males are more susceptible to diseases than females.

Generally, female mosquitoes feed on animal blood, including humans. One study concluded that unfed virgin female insects are strongly attracted to humans than males and tries to suggest that some people have stronger "attraction" to mosquitoes than others (Hamilton and Ramsoondar, 2008). Some of these "attractions" were identified by Kline *et al.* (2003) in *Aedes* aegypti, the dengue mosquito. According to the other researches, female malarial mosquitoes were governed by olfactory cues that may be responsible for various behaviors of female mosquitoes. Recent evidence pointed that there exists a human-specific kairomones that affects the host-seeking mosquitoes (Takken and Knols, 1999).

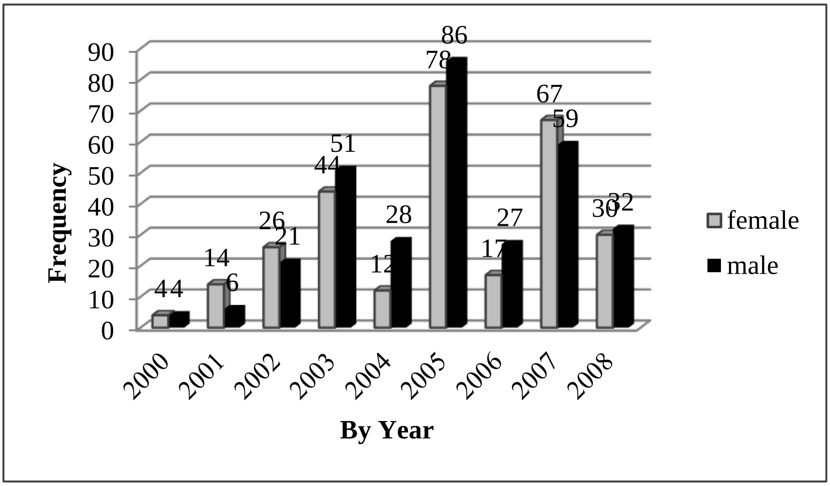
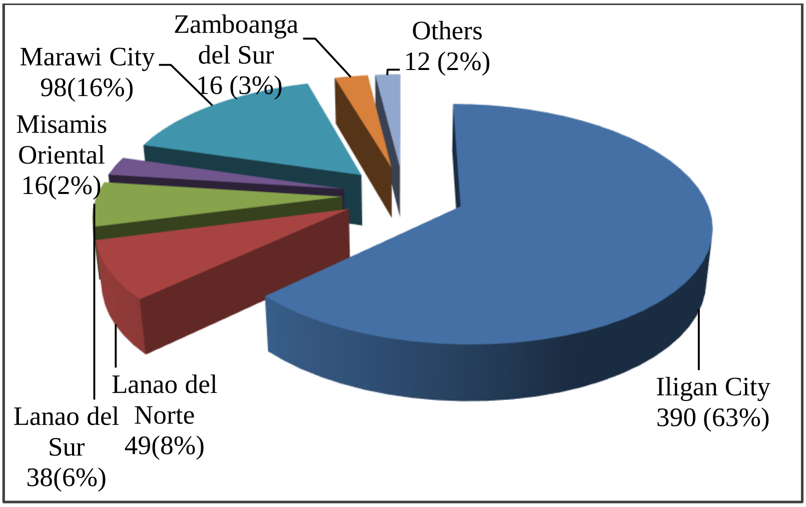


Figure 5. Distribution of DHF according to Gender for 2000-2008

Figure 6 shows that majority of the respondents with dengue cases are coming from Iligan City which comprises more than 60% of the total cases; followed by Marawi City with 98 dengue cases or 15.83% of the total cases;12 or 2% of dengue cases belongs to other location such as Misamis Occidental, Bukidnon and some areas in Davao Region. This simply implies



*Based on reported cases since 2000-2004

Figure 6. Distribution of Location* of the Respondents

that since MSH is located in Iligan City, thus majority of the dengue cases reported are from this area.

3.1 Forecasting

This section deals on developing a univariate time series model for the monthly DF and DHF cases in MSH, Iligan City using ARIMA Model.

Figure 7 presents the non-stationary trend of monthly dengue cases in MSH from the year 2000 to 2008.

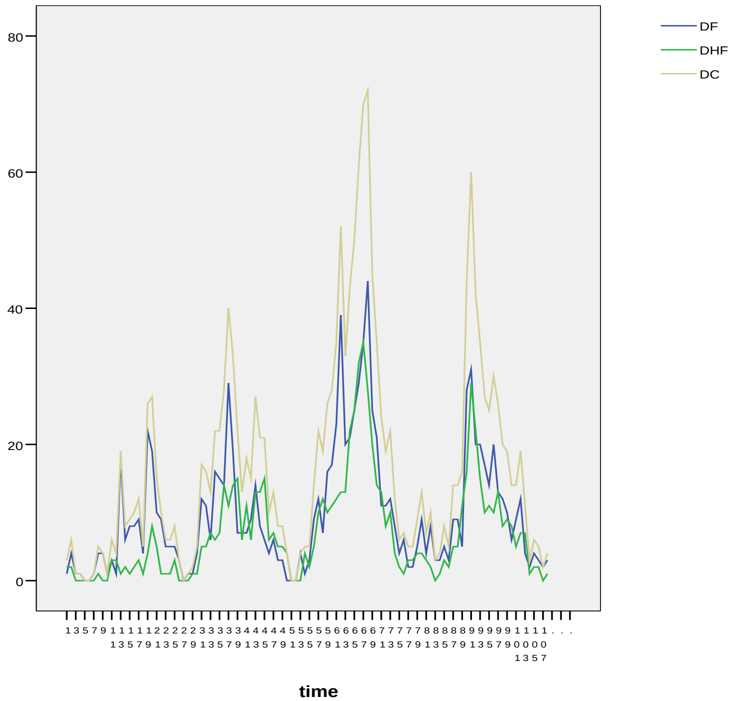


Figure 7. Non-stationary Trend of Monthly Dengue Cases in MSH

The trend of the graphs revealed strong and positive autocorrelation. There does not seem to be a significant trend or any obvious seasonal pattern in the data.

3.2 Dengue Fever (DF)

Figure 8 shows that the sample autocorrelations are very strong and dies down extremely slowly. This suggests that the process is non-stationary (not constant in mean and variance) and recommends a first order differencing (considering a difference of previous and present values). Further reveals that the mean fluctuates around zero and showed constancy of variance after first-order differencing. Figure 9 and 10 shows the autocorrelation and partial autocorrelation plot of the differenced data.

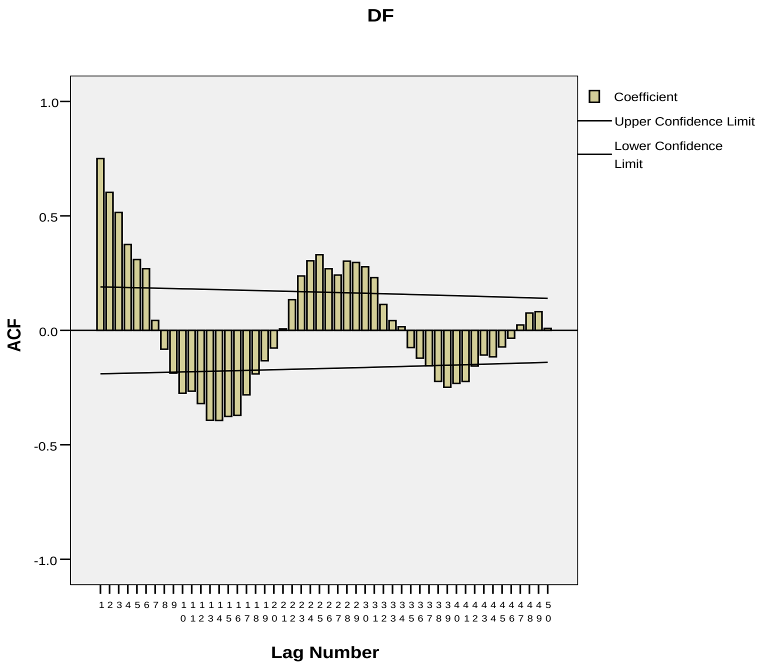


Figure 8. Autocorrelation Plot of the Monthly DF Cases

Figure 8 shows that the sample autocorrelations are very strong and dies down extremely slowly. This suggests that the process is non-stationary (not constant in mean and variance) and recommends a first order differencing (considering a difference of previous and present values). Further revealed that the mean fluctuates around zero and showed constancy of variance after first-order differencing. Figures 9 and 10 show the autocorrelation and partial autocorrelation plot of the differenced data.

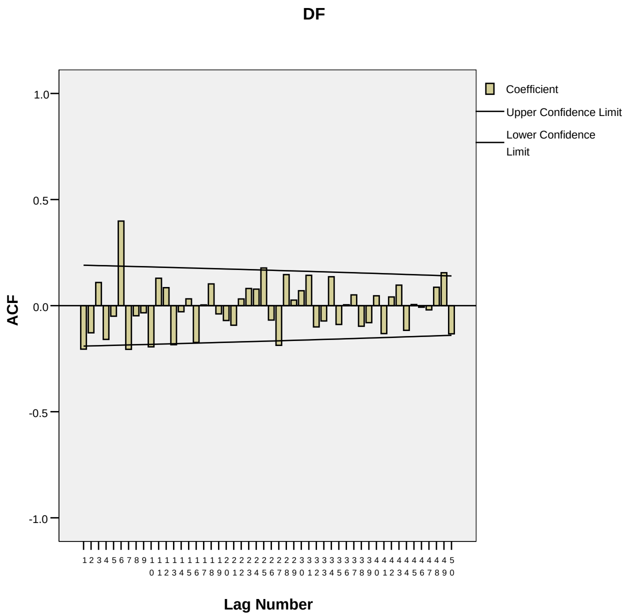


Figure 9. Autocorrelation Plot of the Differenced DF Data

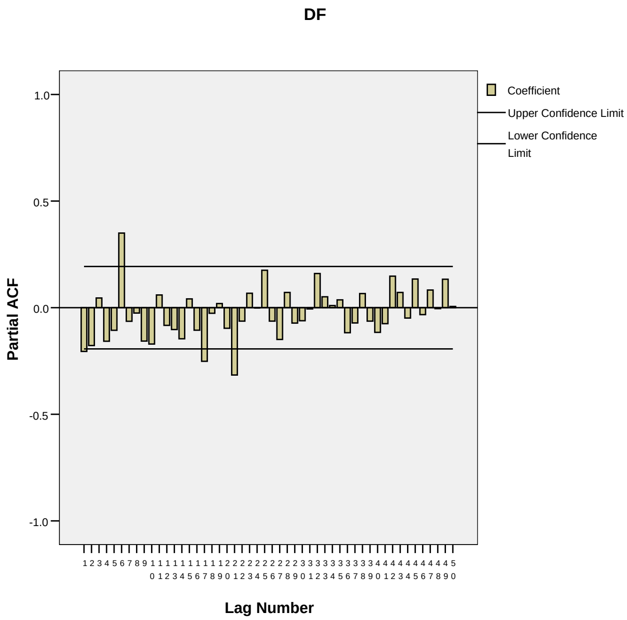


Figure 10. Partial Autocorrelation Plot of the Differenced DF Data

Figure 9 shows that only the autocorrelation at lag 1 is quite significant. The autocorrelation plot together with run sequence of differenced data suggests that the difference data is stationary. Based on the plot, an MA (1) model is suggested for the differenced data. To consider some possible inclusion of autoregressive model, an evaluation of partial autocorrelation plot is needed as shown in Figure 10.

Figure 10 reveals that the partial autocorrelation dies down after first lag and consider significant (beyond lower confidence limit). Even though there are some significant lags after lag 1 but not fall at seasonal lag so they are consider not significant. This simply recommends an AR (1) model for the differenced DF data.

As evaluated, it was shown that the tentative model is first-order autoregressive, first order differencing and first order moving average. To estimate the parameter, Table 1 below presents the concise result.

Table 1. Parameter estimates of the proposed ARIMA (1,1,1) model for the Dengue Fever (DF) cases

Model	Estimates	Std. Error	t	Approx Sig.
AR (1)	0.780	0.086	9.027	0.000***
MA (1)	0.985	0.085	11.586	0.000***
Constant	0.054	0.088	0.620	0.537

****-significant at 0.001 level of significance*

Table 1 reveals that the estimates of AR (1) and MA (1) are all statistically significant, which could probably be included in the model. This implied that the parameter estimates are significantly different from zero. The forecast model for the differenced DF data, Y_t is an ARIMA (1,1,1) model:

$$Y_t = 1.78Y_{t-1} - 0.78Y_{t-2} - 0.985a_{t-1} + 0.054 \tag{2}$$

where:

Y_t represented the number of DF cases at time t
Y_{t-1} represented the number of DF cases at time $t-1$
Y_{t-2} represented the number of DF cases at time $t-2$
a_{t-1} represented white noise process at time $t-1$

To further evaluate the proposed tentative model in terms of its accuracy and predictive ability, a predicted versus residual values plot of the differenced DF data is presented in Figure 11.

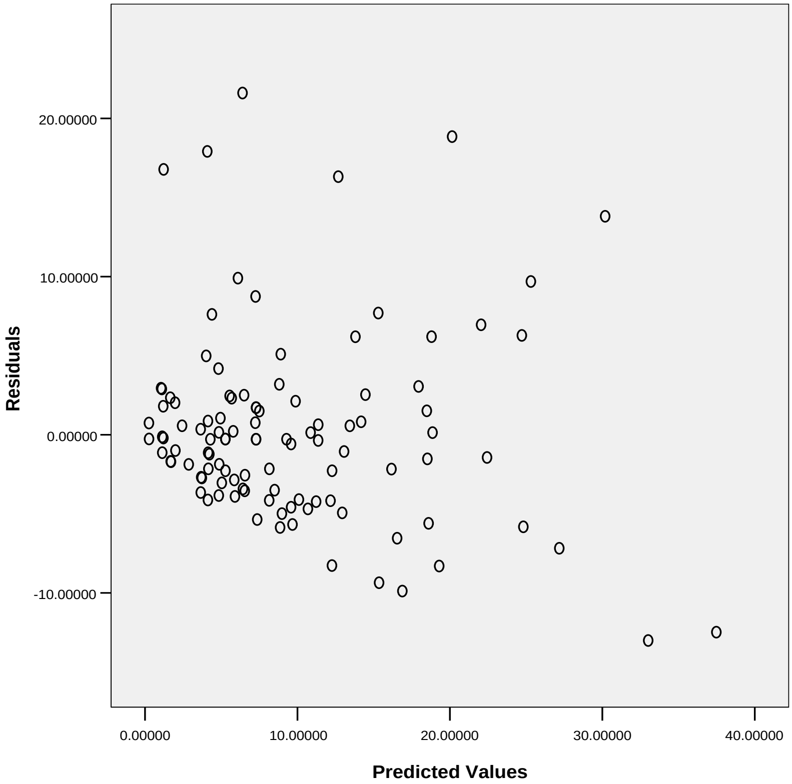


Figure 11. Predicted values versus Residuals of the Differenced DF Data

Figure 11 shows that the residuals in the model did not exhibit significant trend in variation as predicted values increased. This further implied that the residuals fluctuate randomly around zero mean. The autocorrelation function of residuals showed no significant spikes (Q Box-Ljung Statistics = 3.13, $X^2_{0.05,32}$ = 18.5)

Figure 12 presents the observed and predicted values of DF cases from 2000-2008.

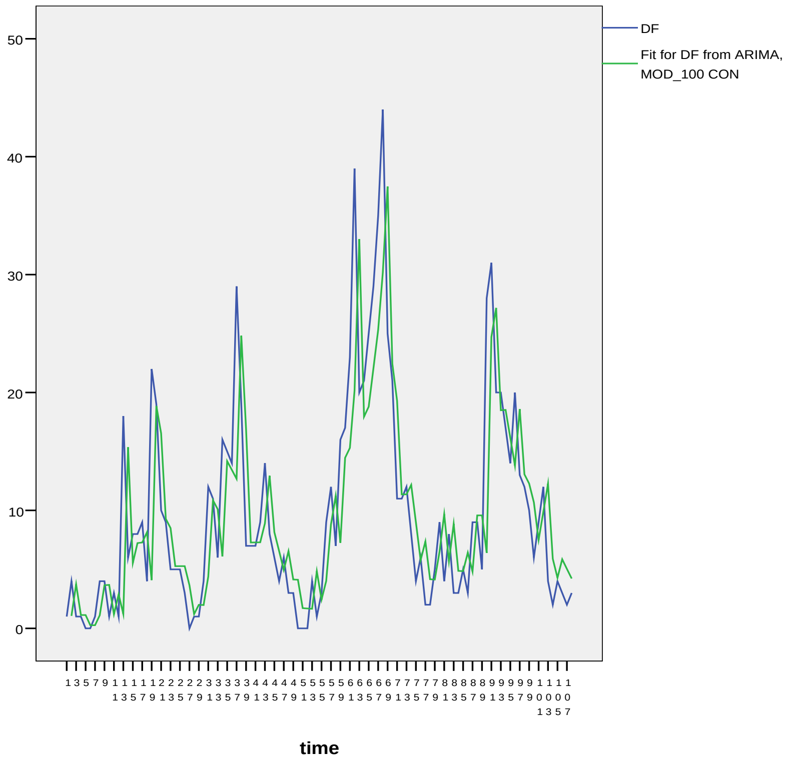


Figure 12. Plot of the Observed and Predicted DF Cases from 2000-2008

3.3 Dengue Hemorrhagic Fever (DHF)

As evidently seen in Figure 7, the graphical trend of DHF data is not stationary and needs some transformation or differencing. Figure 13 sufficed the proof of its non-stationary series since the autocorrelation function dies down extremely slowly as lag number increased.

Figure 13 reveals that the autocorrelation function geometrically decayed at several lags which constitute non-stationary series. Further implication showed that most of the lags fall outside the 95% confidence limit. This showed that the series is not stationary and needs a transformation by taking a natural log (not constant in variance). The autocorrelation and partial autocorrelation plot of the transformed series is presented in Figure 14 and 15.

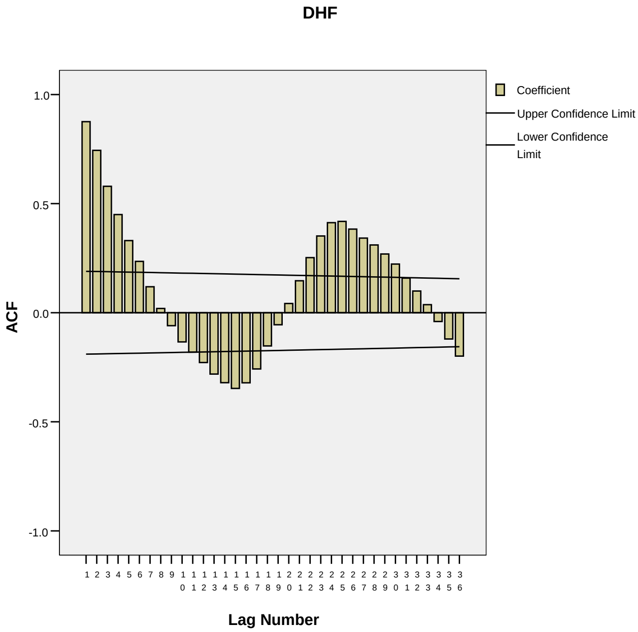


Figure 13. Autocorrelation Plot of the Monthly DHF Cases

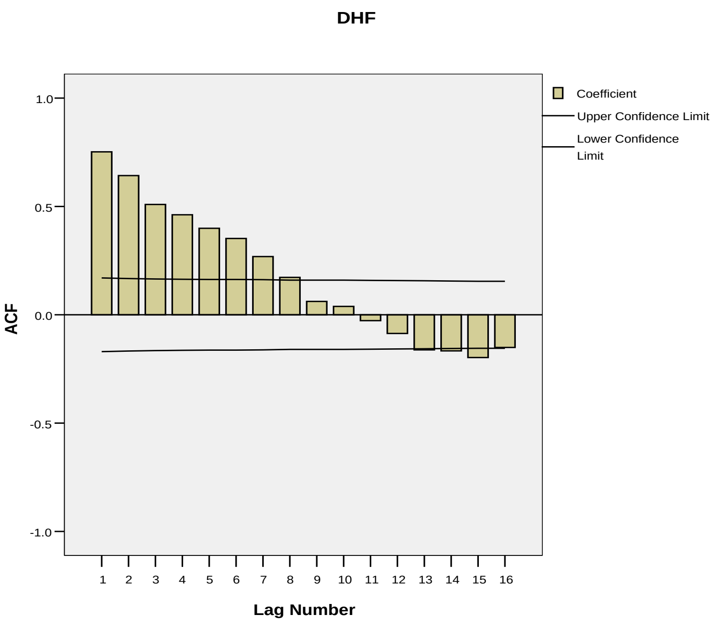


Figure 14. Autocorrelation Plot of the transformed DHF Data

Figure 14 depicts that the autocorrelation function of the natural log DHF data dies down extremely slowly. This implied that no significant tentative model available for moving average operator of order *p*. Figure 15 shows that the partial autocorrelation function dies down after lag 1. This suggested that lag 1 is a significant spike. A proposed first-order autoregressive AR (1) is recommended.

To determine if the parameter estimate of the tentative forecast model is not significantly different from zero, a model estimates is performed.

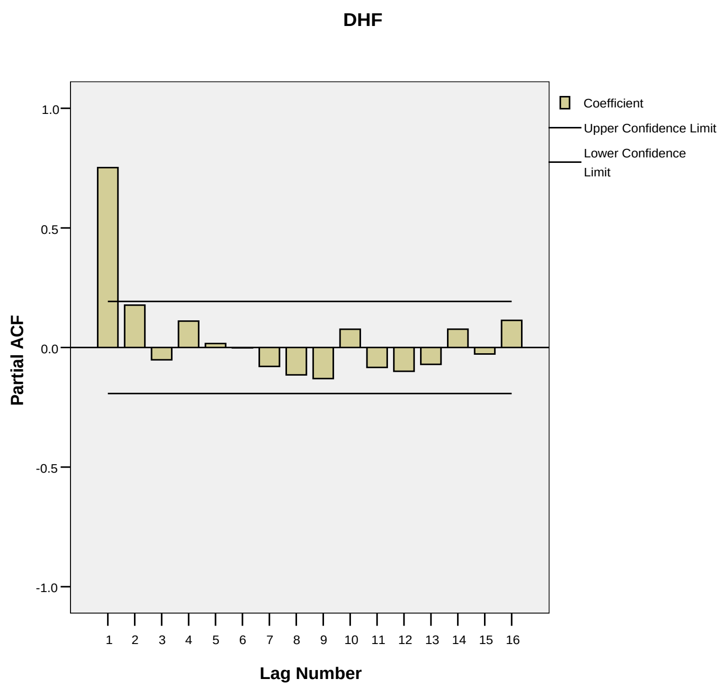


Figure 15. Partial Autocorrelation Plot of the transformed DHF Data

Table 2 reveals that the parameter estimates of AR (1) model is significantly different from zero ($p < .001$). The forecast model for the natural log transformed DHF data is given by:

$$Y_t = 0.822Y_{t-1} + 1.435 \tag{3}$$

where:

Y_t represented the natural log number of DHF cases at time *t*

Y_{2-1} represented the natural log number of DHF cases at time *t-1*

a_{t-1} represented white noise process at time *t-1*

Table 2. Parameter Estimates of the Proposed ARIMA (1,0,0) Model (with natural log transformation) for the Dengue Hemorrhagic Fever (DHF) Cases

Model	Estimates	Std. Error	t	Approx Sig.
AR (1)	0.822	0.056	14.698	<.001***
Constant	1.435	0.304	4.722	<.001***

****-significant at 0.001 level of significance*

Figure 16 shows that the residuals of the second differenced DHF data did not exhibit significant trend in variation (either linear or not) as predicted values increased. This further suggested that the residuals fluctuate randomly around zero mean. The autocorrelation function of residuals showed no significant spikes (*Q* Box-Ljung Statistics = 5.08, $X^2_{0.05,32}$ = 18.5)

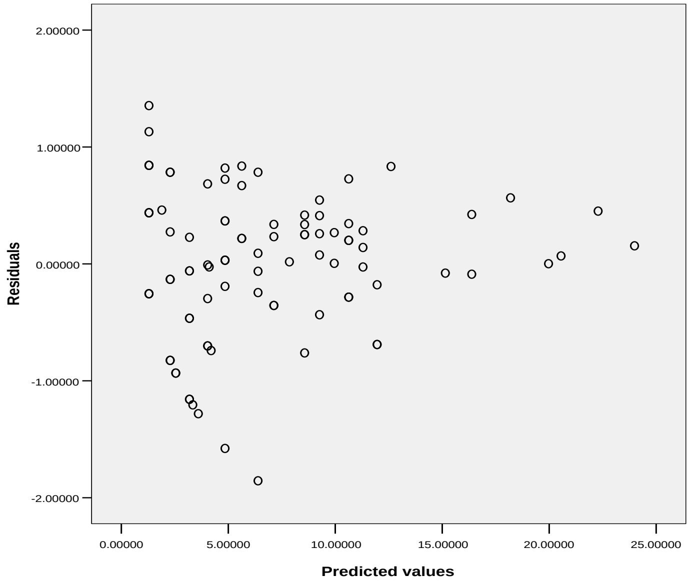


Figure 16. Predicted versus Residuals of the transformed DHF Data

Figure 17 below presents the observed and predicted values of DHF cases from 2000-2008.

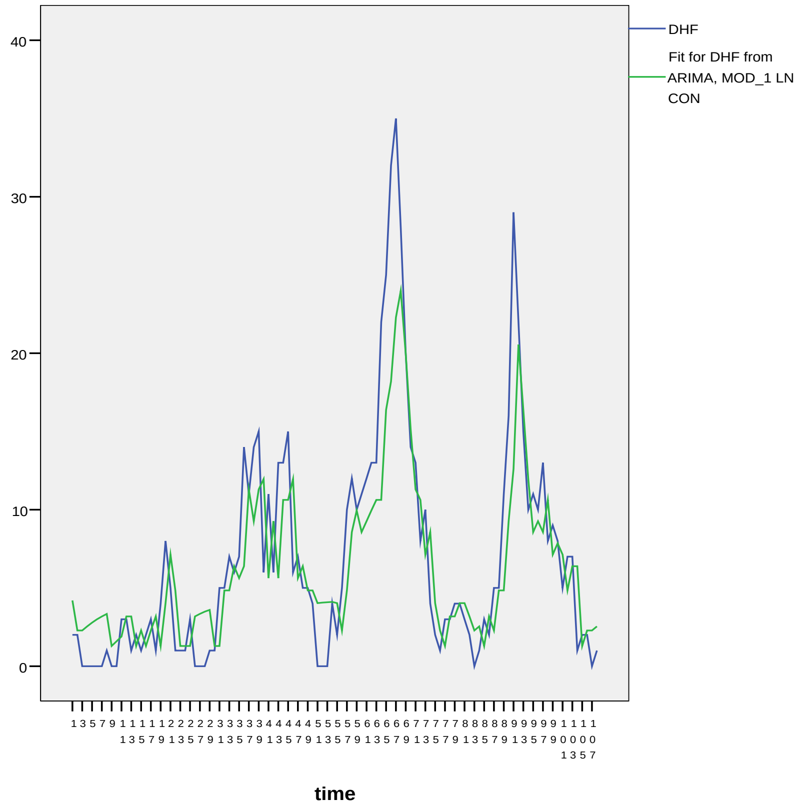


Figure 17. Plot of the Observed and Predicted Values of DHF Data

4. Conclusion and Recommendation

The study concluded that both sexes tend to be more susceptible in acquiring both DF and DHF ($p > .05$). In terms of age, younger patients contact DHF more than DF. Also, it has been noted that alternating increase-decrease pattern of the number of cases of these diseases is consistent throughout the study period.

The forecast curve models developed by the researchers showed consistent trend with the pattern of observed values. The autocorrelation functions of residuals among the three forecast models were not significantly different from zero or the residuals are uncorrelated. Therefore, the three forecast curve models developed are accurate and useful for prediction of possible occurrences of dengue cases as the data per se.

Recommendations of the study includes: (1) the identification of the dengue serotypes causing these diseases in Iligan and nearby vicinities; (2) extension of the research locale which will include private and public hospitals; (3) correlation of other personal data from patients which includes stress factors, diet, home environment and blood type; (4) the forecast models developed offers the potential for improve contingency planning of public health intervention in Iligan City; and (5) the introduction of the derived result to the public via forums.

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