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Article

Statistical-Demographic Analysis of Infant's Mortality in Lagos State, Nigeria

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Abstract

This study was aimed at evaluating the infant's mortality according to the available data from General Hospital, Shomolu, Lagos. Data were collected from the hospital records from 2009 to 2018 (ten years) with approval given by the Lagos State Health Service Commission. The data describe the age and gender distributions of the mortality recorded as well as the time index. The series is a monthly data type of record which captures the mortality at regular interval. The significance of the gender mortality variations was put to test in order to evaluate if the difference observable has any concrete information it holds. However, it was observed using independent T-test at alpha level of 0.01 that, there is no significant difference between average death of male babies and female babies. Furthermore, chi-square test for independence was used to evaluate the dependence between the age and gender factors and was observed that, there is no dependence between age and gender factors. Time series analysis was therefore employed to study the trend of the data as well as to assess the stationarity status of the series. The ARIMA (Autoregressive Integrated Moving Average) was employed to model the series and forecast of future expected occurrence was done. It was noted from the forecasted report that, there will be a slight reduction in infant mortality for the year 2019-2022. Since there is a slight reduction in the prediction for the year 2019 – 2022, more efforts should be put into training the medical staff as well as provide improved infrastructural facilities in order to maintain the reduced infant's mortality rate or bring it down to zero level.

Keywords: Infant, Mortality, Children's Health, Environmental or behavioral risk factors.

1. Introduction

Statistics is very versatile and plays a more role in every area of human existence and health inclusive. Oxford Dictionary defined health as a state of being free of sicknesses and injuries [1]. It is the physical and mental wellness or a condition of wellbeing [2]. Infant mortality is defined as the death of a live born child between the day of birth and span of 12months according to United Nation International Children Fund [3]. Its importance can be seen in the fact that; it defines the state of wellbeing of a population. This underscores why outmost attention must be placed on the health of mothers and child in any nation. Infant mortality rate is the number of deaths under one year of age occurring among the live births in a given geographical area under a given year, per one thousand live births occurring among the population of the given geographical area during a given year [4].

There are various reasons behind infant mortality and morbidity such as high numbers of births per mother with short spacing between births, poor weaning foods, use of infants' formulas (cow's milk), inadequate healthcare delivery system, unhygienic practices (sanitations), poor feeding practices and low educational attainment of nursing mothers. Infant survival should be a major policy goal for Nigeria, because of the multiple short-term and long-term effects on human and economic development for the progress of a society. Rates of infant mortality are sensitive indicators of a broad

range of factors affecting children's health. As such, infant mortality is an important indicator of child health problems, and changes in infant mortality are a signal of factors affecting child health more badly.

In addition to its role as a general gauge of child health, infant mortality itself represents an important health problem. It is well to remember that infant death rates are the highest of any age group less than 65years. Infant mortality is death that occurs within the first year of babies' life and this can be further divided into neonatal (first 28 days) and post neonatal mortality (after28th days till a year). According to [5] Infant mortality is defined as the death of a live born infant between birth and exact age one. Infant mortality rate is the probability of a child born in a specific year or period dying before reaching the age of one, if subjected to current age specific mortality rates of that period. This is because mortality tends to decline more slowly among infants than among children aged 1 to 5. The neo natal period represent a very delicate time for the survival of a child and according to [6] it includes all death that occurs within the first 28 days after birth and can be further broken down to early neonatal (0 – 6days) and late neonatal (7 – 28 days).

It was observed that neonatal deaths and stillbirths stem from poor maternal health, inadequate care during pregnancy, inappropriate management of complications during pregnancy and delivery, poor hygiene during delivery and the first critical hours after birth, and lack of newborn care [7]. The report also stated that, some babies die after birth because they are severely malformed, are born very prematurely, suffer from obstetric complications before or during birth, have difficulty adapting to extra uterine life, or because of harmful practices after birth that lead to infections Post-neonatal mortality is most often caused by infectious diseases, such as pneumonia, tetanus, and malaria. An important factor in reducing post neonatal mortality is adequate nutrition, particularly breast milk, which provides babies with both the nourishment and the antibodies to fight infectious diseases [8]. Breast milk can be supplemented or substituted by mixing formula; however, it is important that clean water is used [9]. Furthermore, it has been discovered that, various factors contributed to infant mortality such as parents' education [10]. Birth interval [11], age of mother [12] and sex of the child [13].

2. Methods

This research makes use of secondary data that was gotten at Shomolu General Hospital Oguntolu, Shomolu, Lagos, accessed with approval from the Lagos Health Service Commission. The Data cover infant mortality records between January 2009 and December 2018 and were grouped into males and females.

To achieve our aim and objectives the following statistical tools were employed.

(a) Descriptive statistics such as Pie charts, Doughnut charts, line graphs were used to identify the level of infant mortality for both male and female.

(b) The independent T-test (alpha = 0.1) was used to test whether there is or no significant difference in the mean values of the male and female infant mortality while Chi square test (alpha = 0.1) was also used to know if mortality is Gender-age dependence. Independent t-test is used in comparing two independent means. It compares two sample means to determine whether the population means are significantly different.

The t-test formula to be used is:

$$t = \frac{\bar{X}_M - \bar{X}_F}{S_p\sqrt{\frac{1}{n_M}+\frac{1}{n_F}}} \qquad \ldots (2.1)$$

Where:

t = test statistic

$\bar{X}_M$ = mean of male

$\bar{X}_F$= mean of female

S_p= Pooled Standard Deviation $= \sqrt{\frac{(n_M-1)S^2{}_M + (n_F-1)S^2{}_F}{n_M + n_F - 2}}$ … (2.2)

Where:

$\boldsymbol{n_M}$ = *number of males*
$\boldsymbol{n_F}$= *number of females*
$S^2{}_M$= *male variance*
$S^2{}_F$= *female variance*

(c) Chi square test (alpha = 0.1) was also used to know if mortality is Gender-age dependence. The chi-square statistic is used to compare the **observed frequency** of some observation with an **expected frequency**. The comparison of observed and expected frequencies is used to calculate the value of the chi-square statistic, which in turn can be compared with the distribution of chi square to make an inference about a statistical problem.

The symbol for chi-square and the formula are as follows:

$$x^2 = \sum \frac{(O-E)^2}{E} \quad \text{... (2.3)}$$

O *is the observed frequency, and*
E *is the expected frequency.*
The degrees of freedom for the one-dimensional chi-square statistic is df $= \boldsymbol{n-1}$
Where ***n*** *is the number of categories or levels of the independent variable.*

(d) Infant mortality rate was also calculated. The infant mortality Rate is calculated using this formula:

$$\frac{Total\ Deaths\ in\ a\ Year}{Number\ of\ Live\ Birth} \times 1000 \quad \text{… (2.4)}$$

Neonatal Mortality rate is calculated using this formula:

$$\frac{Number\ of\ Death\ within\ 48\ days}{Total\ Number\ of\ Live\ Birth} \times 1000 \quad \text{… (2.5)}$$

Sex ratio is:

$$\frac{All\ Males}{All\ Females} \times 100 \quad \text{… (2.6)}$$

(e) Time series analysis was used to get the trend values also with R-software and forecasted values for Six years (2019-2022) with R-Software. Method of Least Squares

Time series model to be used for the research work is:

$$\boldsymbol{Y_t} = \alpha + \beta t \quad \text{... (2.7)}$$

Using Least Squares Method to estimate the parameters

Where:

$\boldsymbol{Y_t}$= Observed value at time t

$\boldsymbol{\alpha}$ = intercept which can be computed/calculated **by**: $\alpha = \boldsymbol{\alpha} = \bar{\boldsymbol{y}} - \boldsymbol{b}\bar{\boldsymbol{X}}$ … (2.8)

$\boldsymbol{\beta}$ = slope which can be computed/calculated by $\boldsymbol{\beta} = \frac{\boldsymbol{n}\sum \boldsymbol{XY} - \sum \boldsymbol{X}\sum \boldsymbol{Y}}{\boldsymbol{n}\sum \boldsymbol{X^2} - (\sum \boldsymbol{X})^2}$ … (2.9)

t = time period during which each data point was collected

3. Results and Discussion

This section shows presentation of data, its analysis and the results of our study.

Table 1: The Mortality Distribution Relative to Age and Gender

Year	Gender	Age	Mortality
Min. :2009	Length:40	Length:40	Min. : 0.00
1st Qu.:2011	Class: character	Class: character	1st Qu.: 2.00
Median :2014	Mode: character	Mode: character	Median: 4.00
Mean :2014	NA	NA	Mean : 5.80
3rd Qu.:2016	NA	NA	3rd Qu.: 8.25
Max. :2018	NA	NA	Max. :18.00

The table 1 describes the variables included in this data as Year is the time defining variable and it shows that the data collected is for the periods between 2009 and 2018. The mortality variable also shows that the maximum recorded mortality over this period is 18. The following plots describe these data visually.

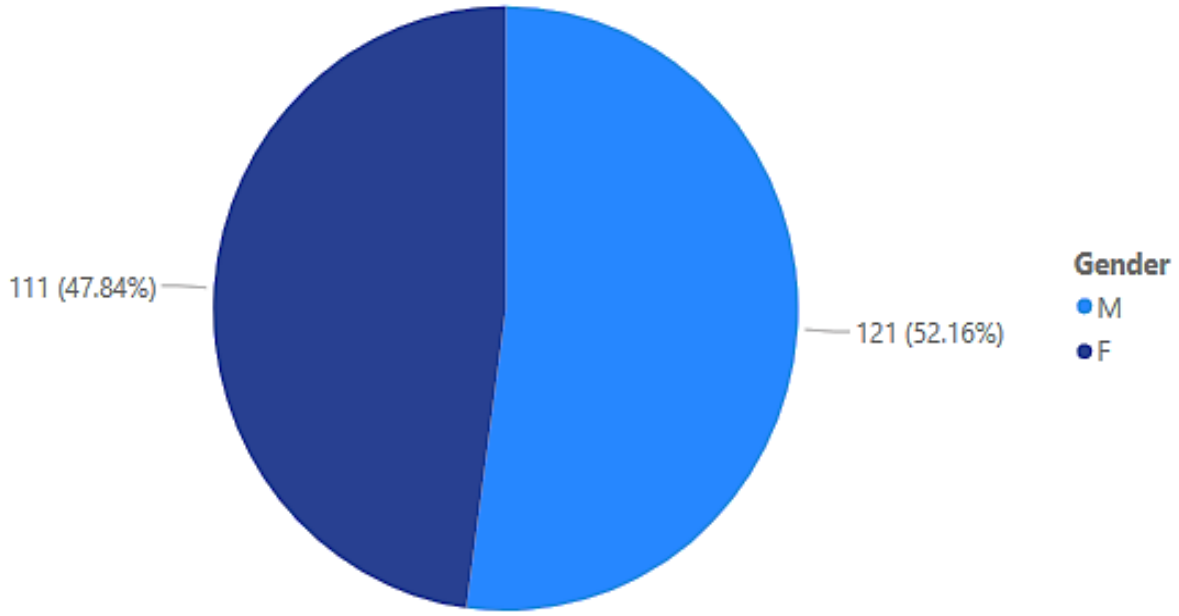

Figure 1: Mortality Distribution by Gender

The chart in Fig. 1 shows the mortality distribution by gender -which is evaluated as 121 male infant mortality and 111 female infant mortality.

Fig. 2 shows the mortality movement by year with the crest value recorded in 2016 and 2018 being the year with the lowest recorded mortality within the time period under study.

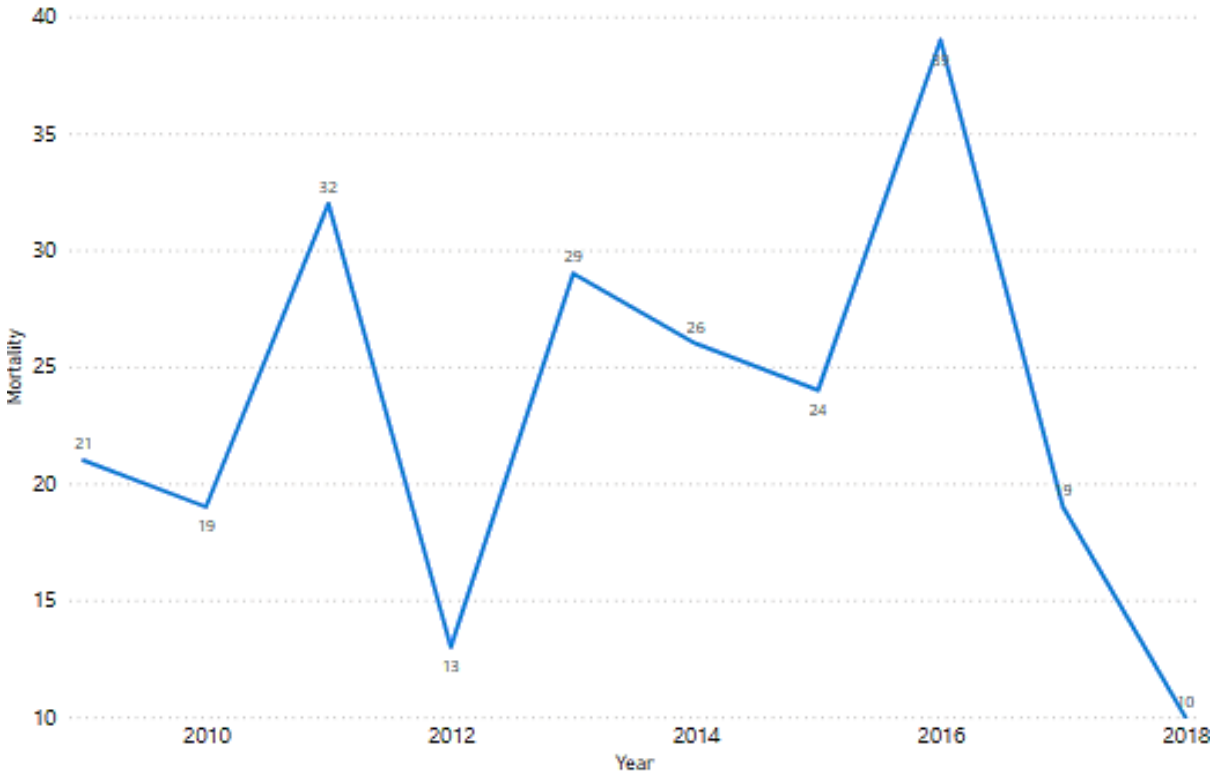

Figure 2: The Graph Showing Mortality Movement by Year

3.1 Difference between male and female infant mortality

The distribution of the mortality recorded relative to gender poses some questions that led to a hypothesis concerning the difference between the mortality recorded relative to the gender (Table 2).

Table 2. Mortality distribution by gender

	Sex	N	Mean	Standard Deviation	Minimum	Maximum
Infant Mortality	Male	20	6.05	5.29	0	18
	Female	20	5.55	5.07	0	17

The hypothesis is given as follows:

H_0: There is no significant difference between the male and female infant mortality

H_1: There is a significant difference between the male and female infant mortality

The independent samples t-test was used to evaluate the difference between these two populations and the results are as presented in Table 3.

Table 3: t-test results

	t-statistic	degree of freedom	p-value	mean difference	95% con. interval of the difference	
test output	0.31	37.94	0.76	0.5	-2.82	3.82

The analysis output shows a mean difference of 0.5 between the two populations, the test statistic for this evaluation is calculated as 0.31 with a significance value of 0.76. The p-value is greater than 0.1(α) and therefore the null hypothesis is retained and the conclusion about this evaluation is that the difference between the male and female infant mortality is not significantly different from zero. Another possible thing to look out for, is the Gender-Age dependence. This is based on the hypothesis that the dependence between gender and age might affect the mortality significantly, hence, we subject this to a statistical test.

Table 4: Age -gender dependence

Gender * Age Cross-tabulation				
		Age		
		0-48days	2-12months	Total
Gender	F	10	10	20
	M	10	10	20
Total		20	20	40

Table 4 shows the distribution of infant mortality in the data used relative to both age and gender. The hypothesis is as follows:

H_0: There is no dependence between Age and Gender
H_1: There is dependence between Age and Gender

Table 5: Chi-square test

Chi-Square Tests					
	Value	**Df**	**Asymp. Sig. (2-sided)**	**Exact Sig. (2-sided)**	**Exact Sig. (1-sided)**
Pearson Chi-Square	.000[a]	1	1.000		
Continuity Correction[b]	.000	1	1.000		
Likelihood Ratio	.000	1	1.000		
Fisher's Exact Test				1.000	.624
N of Valid Cases	40				

a. 0 cells (0.0%) have expected count less than 5. The minimum expected count is 10.00.

b. Computed only for a 2x2 table

The analysis result (Table 5) shows that the significance value (p-value) of this evaluation is 0.624 which is greater than 0.1(α), we therefore retain the null hypothesis and conclude that there is no dependence between the age and gender.

Table 6: Distribution of the Infant Mortality Rate

Year	Infant Mortality Rate
2009	37.997
2010	30.441
2011	48.780
2012	19.847
2013	41.076
2014	33.373
2015	31.746
2016	47.045
2017	30.303
2018	21.207

The table 6 above shows that, infant mortality rate for the ten-year period was not stable. However, it was lowest in 2012 and followed by 2018. This indicates that, the health of the community improved.

Table 7: Distribution of the Neo-Natal Mortality Rate

Year	Neonatal Mortality Rate
2009	27.634
2010	18.265
2011	41.159
2012	10.687
2013	31.161
2014	28.605
2015	30.423
2016	39.807
2017	20.807
2018	14.682

Table 7 shows that, neonatal mortality rate for the ten-year period was not stable. However, it was lowest in 2012 and followed by 2018. This indicates that, the health service provision by the Medical centre has improved with respect to infants.

3.2. Time Series Analysis.

Time series analysis was carried out to evaluate the trend in the data as well as modelling ARIMA to explain the variability observed overtime and then the model will be used to project future occurrences.

3.3 Test for unit root (Stationary)

The series was tested using the Kwiatkowski–Phillips–Schmidt–Shin (KPSS) test. The hypotheses and the decision rule are as follows:

H_0: Series is stationary

H_1: Series is not stationary

Table 8: Test for unit root stationary

KPSS Trend	Truncated lag parameter	p-value
0.1073	4	0.1

The output shows that the significance value of the test carried out is 0.1073 which is greater than 0.1(α), we therefore retain the null hypothesis and conclude that the series is stationary. The trend of the series is accessed by decomposing the series into its three components which are the seasonal variation, trend, and random error. The plot of these components is presented as follows:

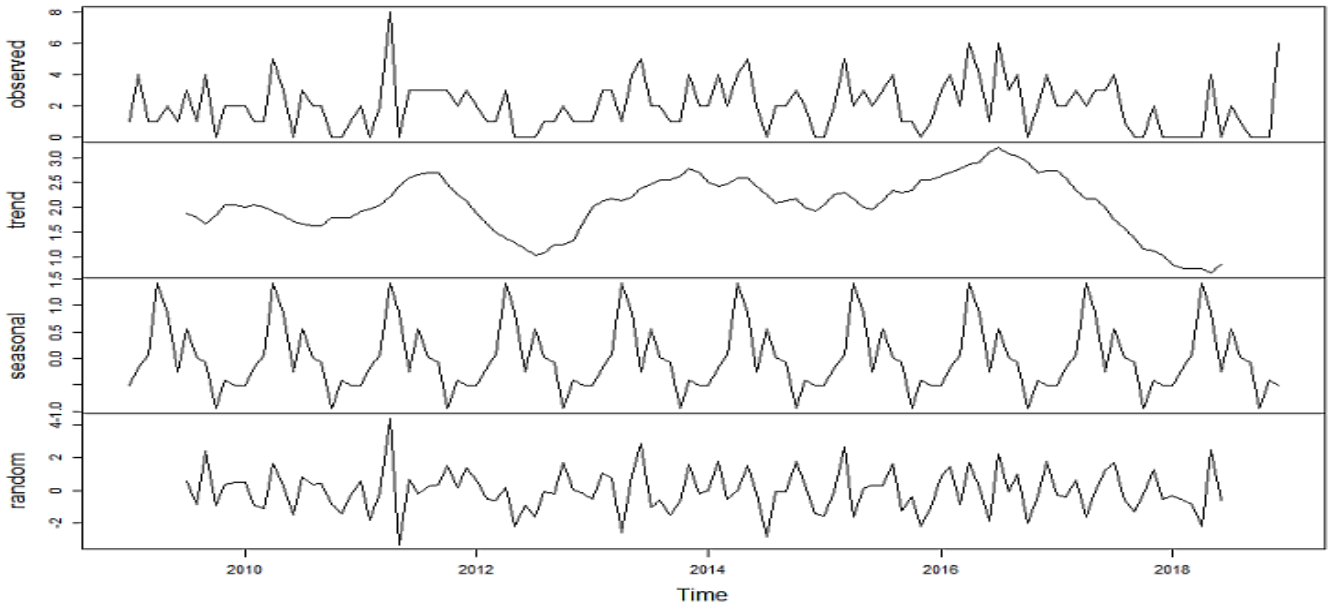

Figure 3: Decomposition of additive time series for mortality

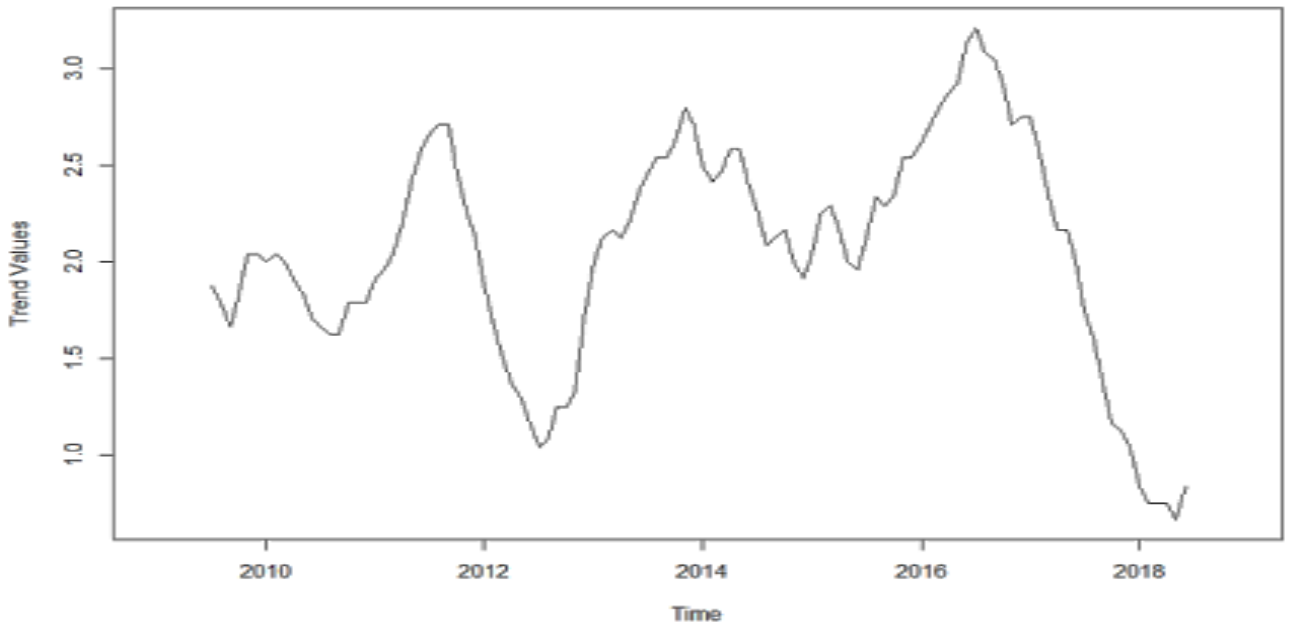

Figure 4: The mortality trend

The Time series was generated with R-software and the first thing done is to check for trend stationary before forecasting and model the series. Auto Correlation and Partial auto Correlation Plots-Are used

to further verify that the series is stationary. The trend is studied such that, one can check the pattern via the charts- the decomposed shows the observed, seasonal, trend, random error. Also, it plots the entirety before breaking it down into trend, seasonal and random error, since the series is stationary. Next is to move into ARIMA model which is shown in Fig. 3 and Fig. 4 , the results are shown with the standard error and the coefficient such that, the lower the AIC (Akaike Information Criterion) the better the model.

3.4 The ARIMA model

The series was modeled using the ARIMA (Autoregressive Integrated Moving Average) technique. The ARIMA was selected as it was auto-selected as the best model by the auto-arima model functionality in R. The returned results are therefore presented below. The following presents the result:

Table 9: Autoregressive integrated moving average for mortality rate

	AR1	AR2	MA1
Coefficients	0.1090	0.0522	-0.9703
Standard error	0.0946	0.0955	0.0317

Model measure	σ^2	Log-likelihood	AIC	ME	RMSE	MAE	MPE	MAPE	MASE	ACF1
Value	2.622	-228.44	464.88	0.05	1.613	1.258	-∞	∞	0.80	-0.008

Forecast

The model was used to project future occurrence or expected future occurrence according to what the model parameters can explain. The following presents the predictions:

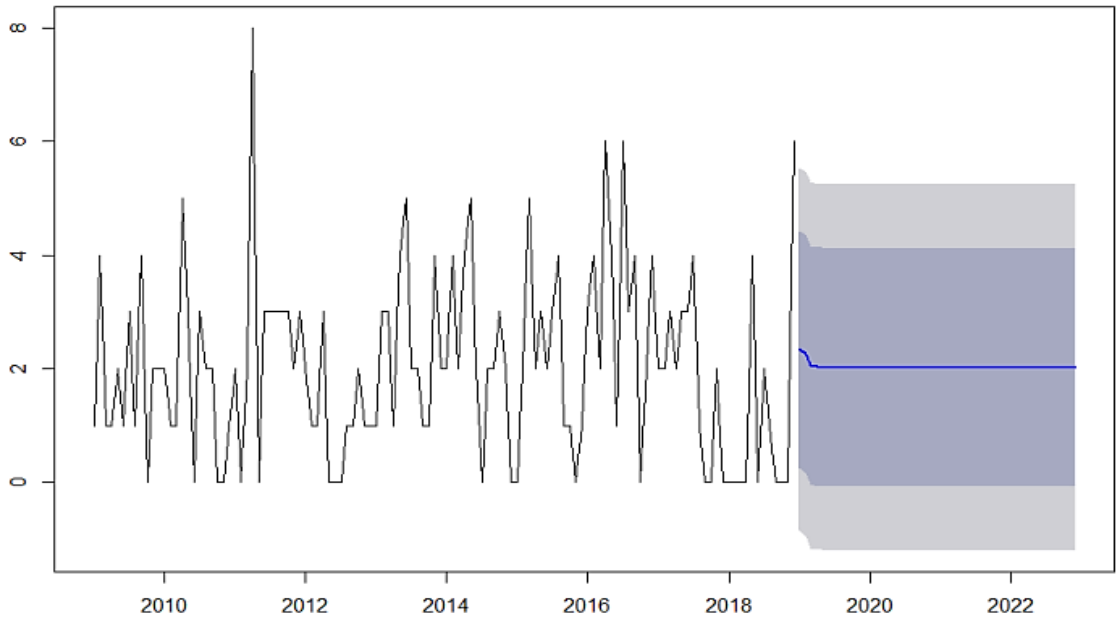

Figure 5: The Plot prediction from ARIMA (2,1,1)

4. Conclusion

This study was aimed at evaluating the infant mortality according to the available data. The data describe the age and gender distributions of the mortality recorded as well as the time index. The series is a monthly data type of records which captures the mortality at regular interval. The significance of the gender mortality variations was put to test in order to evaluate if the difference observable has any concrete information it holds. The independent sample t-test was used for the difference evaluation while a further chi-square test for independence was used to evaluate the dependence between the age and gender factors. Time series analysis was therefore employed to study the trend of the data as well as to assess the stationarity status of the series. The ARIMA (Autoregressive Integrated Moving Average) was employed to model the series and forecast of future expected occurrence was done.

5. Recommendation

(a) To maintain lower level of infant mortality, the government should make more effort on child care through the provision of better facilities and further increase the number of health workers.
(b) The Government should work more on the expansion of Shomolu General hospital Shomolu, Lagos.
(c) More training of medical Staff
(d) More emphasis should be laid on the practices of reproductive such as breastfeeding, spacing children every two or three years and visiting doctor in the hospital for care.
(e) Shomolu general Hospital has really recorded a low infant mortality rate, should not stop at that but implement measure to make it zero level of infant mortality.

This study focused on the behavior of the infant mortality series obtained from Shomolu Local Government. There is no significant difference between male and female mortality so the mortality is not gender based. It was observed that infant mortality in Shomolu General Hospital recorded the highest number of infant deaths in 2011 and the lowest in 2012. The study also revealed seasonality in infant mortality. Most deaths were recorded between February and July. It was also revealed that infant mortality varied by gender and year. The forecasted under-five mortality shows a decline in infant mortality for the years 2019, 2020, 2021 and 2022. Looking at the trend report, infant mortality is generally on decrease over the years. This is an indication that the state of health in Lagos state in particular is improving. However, it is observed that neonatal mortality rate is above half of infant mortality rate. this shows that death of infant is more health facility based than environment so, our health facilities in the hospitals need improvement.

Furthermore, the infant mortality rate does not follow a fixed pattern which is high in 2011 and low in 2012. More deaths are recorded between 2016-2018 from the past report in the hospital and it was noted from the forecasted report that, there will be a slight reduction in infant mortality for the year 2019-2022.

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